# The American Journal of Surgery

EDITED BY THURSTON SCOTT WELTON, M.D.

November 1945

Urology . Biliary Surgery

Vascular Surgery . Proctology

Gynecology . Orthopedic Surgery

*Fifty-fourth Year of Continuous Publication*

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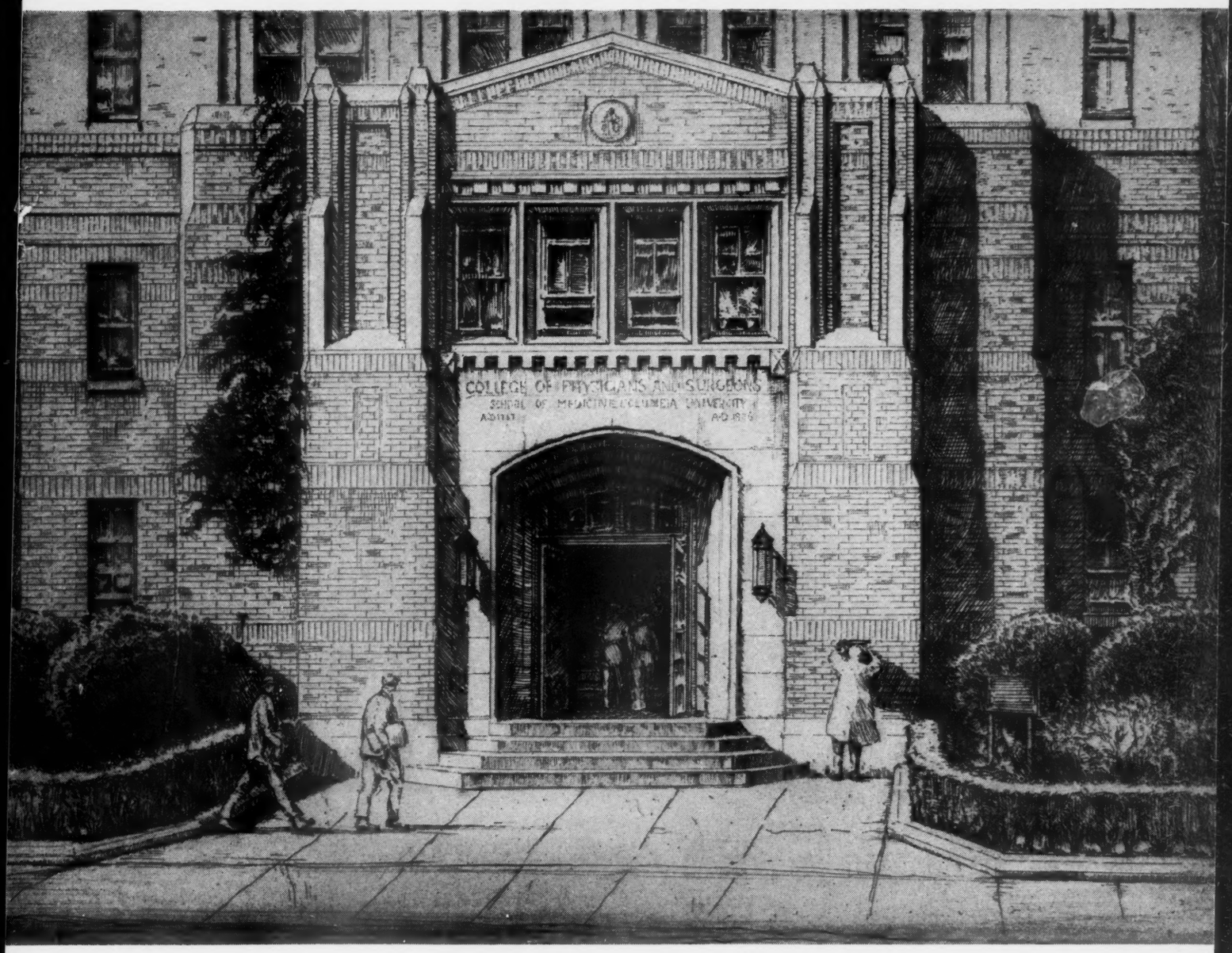


FROM AN ORIGINAL ETCHING BY ERNEST D. ROTH

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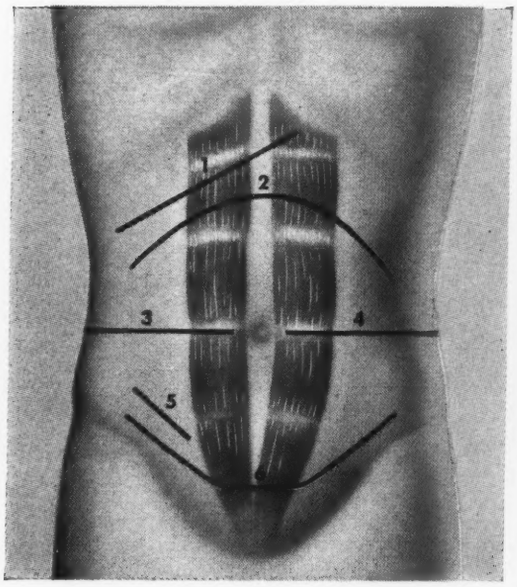
# *Incisions that Minimize*

INCISIONS which offer maximal assurance against sutures pulling through the tissues eliminate a principal cause of wound disruption.

Sutures hold most securely if the connective tissues within the wound are approximated in such a manner that the sutures must pull against the fibres within these layers. This is possible only when connective tissues are cut parallel to the direction of their fibres. In the anterior abdominal wall, this is usually best accomplished through a transverse initial skin incision.

In suturing transverse incisions, no attempt is made to suture muscle—only the surrounding sheath. Approximation of the muscle edges is further aided by keeping the patient in a semi-reclining position with knees partially flexed.




1. For gall bladder, common duct, head of pancreas.
2. Resection of stomach, transverse colon.
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5. Appendectomy.

*6. Pelvic surgery, resection of sigmoid.

## TRANSVERSE INCISION OF LOWER ABDOMEN

The transverse incision across the lower abdomen provides a wide exposure of the pelvic organs, the rectum, the sigmoid and other pelvic structures. Resections and anastomoses can be performed through it which are not possible through the longitudinal incision.

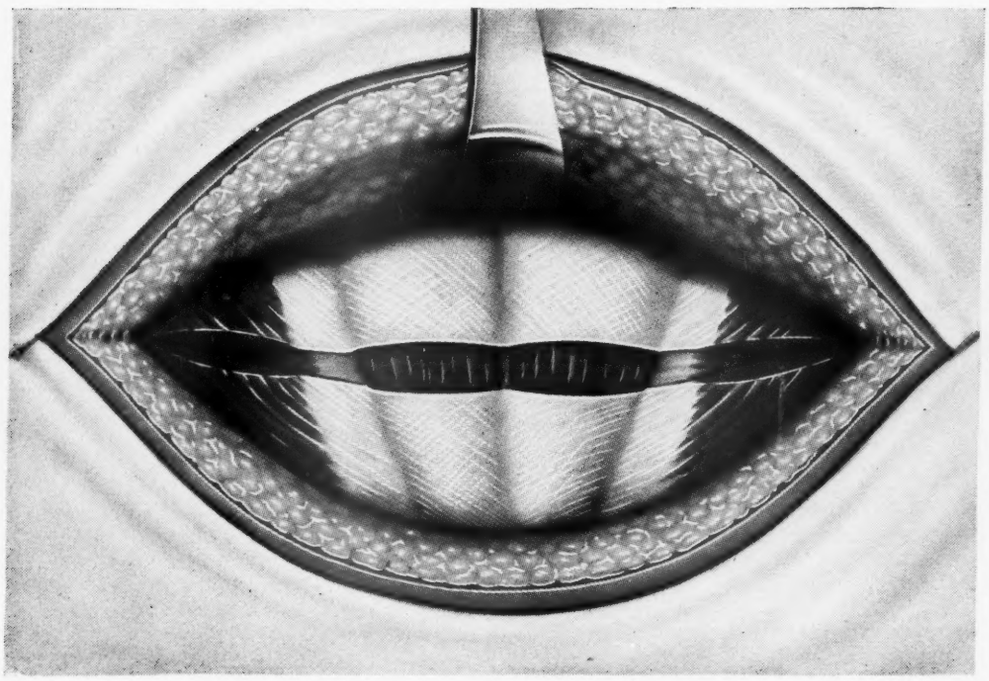
The construction of this incision takes advantage of certain anatomical configurations. These are (1) the thinning and narrowing of the lower ends of the rectus muscle, (2) the termination of the posterior rectus sheath on a level just below the anterior superior spines and (3) the prolongation of the apex of the urinary bladder above this level toward the umbilicus.

### MAKING THE INCISION

The skin incision is made completely across the lower abdomen starting from the anterior superior spine on one side, and curving downward, following the crest of the pelvis at a distance of two fingers' breadth, ending at the other anterior superior spine. It is usually made in a flexion crease. The subcutaneous fat and the anterior rectus sheath are incised in the same direction exposing the recti. The muscles are divided close to the symphasis pubis—i.e. through their tendinous portion, leaving stumps only long enough for resuturing. The severed muscles are retracted upwards until the incision in the posterior sheath can be made about one-half inch above the lower edge of this structure or almost directly between the anterior superior spine. When the peritoneum is incised a long prolongation of the bladder

# Wound Disruption

NUMBER SIX
OF A SERIES

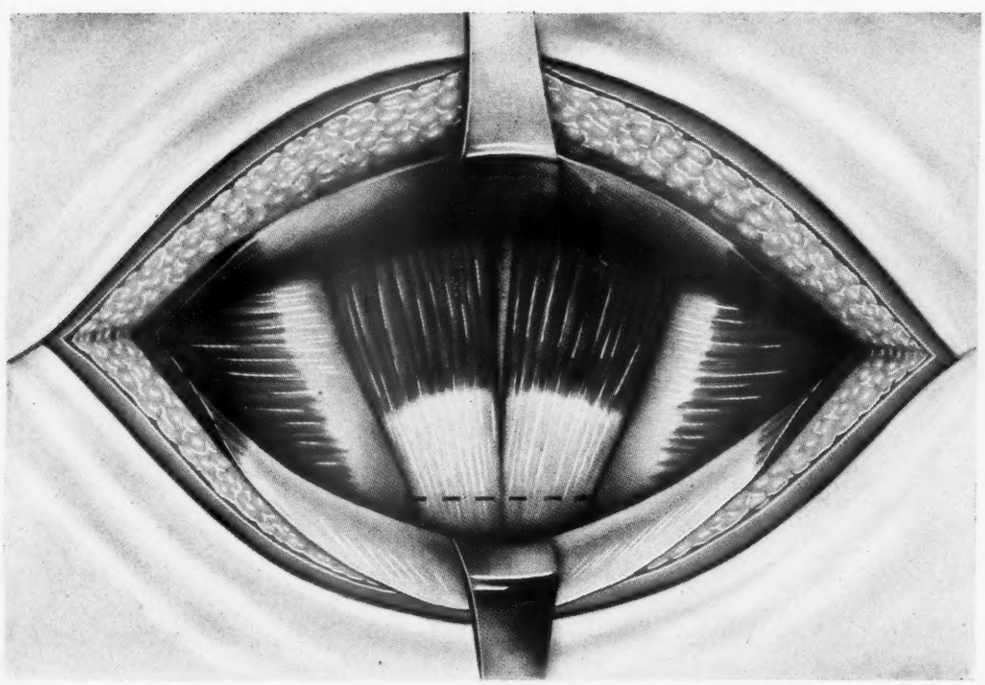


*Exposure of external oblique muscles and fasciae.*

apex must be watched for. The inferior epigastric arteries are clamped and ligated on either side of the rectus muscle when the posterior sheath is incised.

## CLOSING THE INCISION

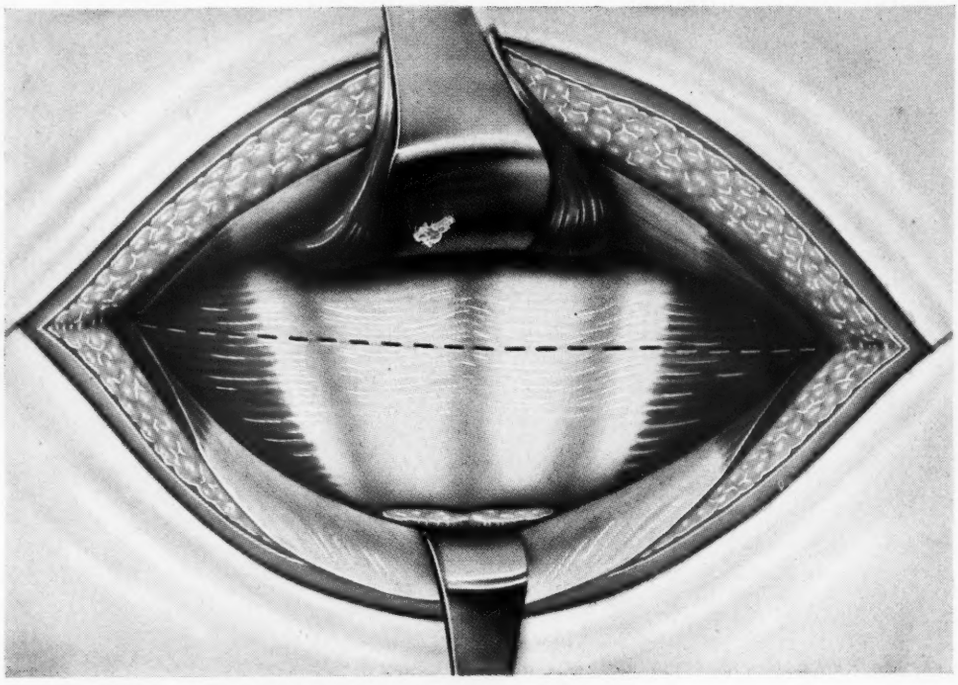
In closing the incision, the posterior sheath is closed with interrupted sutures. The muscles are laid down over this suture line and each is sutured to its stump by two interrupted



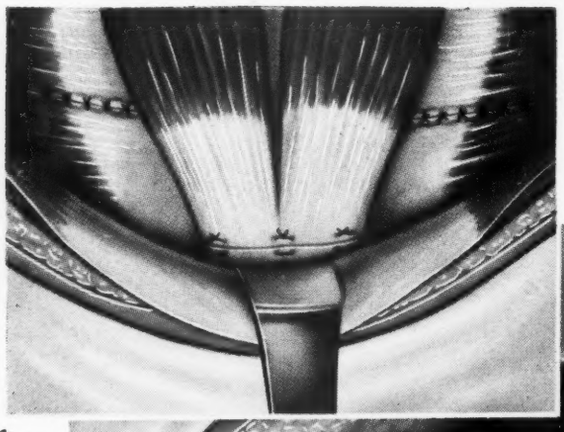
*External oblique fascia has been cut transversely and retracted (exposing recti). Incision in recti indicated by dotted line.*

# *Incisions that Minimize Wound Disruption*

*(Continued from Preceding Page)*

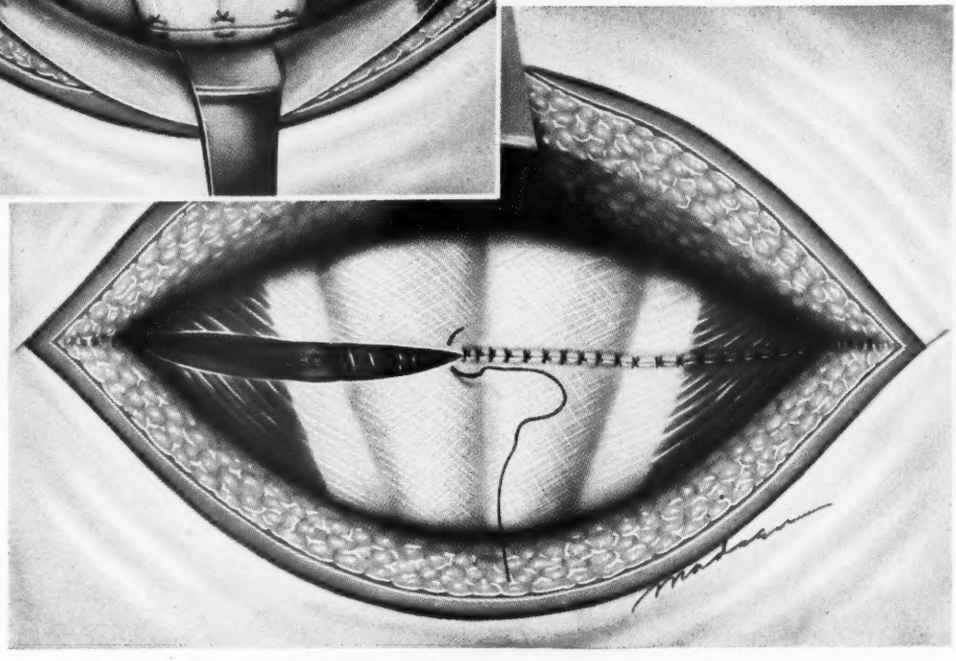


*Recti have been cut in fibrous portion and retracted cephalad. Incision in posterior rectus sheath indicated by dotted line*



mattress sutures. The anterior sheath is closed with interrupted sutures and the skin with interrupted skin sutures.

*(Above) Suture of posterior sheath completed. Recti sutured.*



*(Right) Closure of anterior rectus sheath.*

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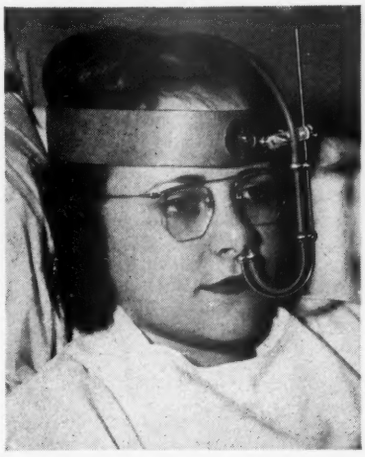

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## *Editorial*


Surgery after the War . . . . . *Carl Beck* 137


## *Original Articles*


Pilonidal Disease. Management of Cysts, Sinuses and Abscesses in Naval Personnel . . . . . *Comdr. Emil Granet and Captain L. Kraeer Ferguson* 139

Stricture of the Male Urethra . . . . . *Major Thomas W. Botsford, Lieut. Col. John H. Harrison and Capt. Burdette E. Trichel* 153


*Contents Continued on Page 3*

*special uses for*

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*thyroid surgery*

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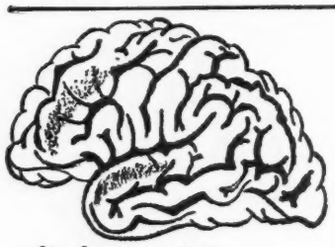

*brain surgery*

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Intussusception. Diagnosis and Treatment . . . . . *Lieut. Comdr. Orland F. Smith* 158

Value of Salpingography in Surgical Diagnosis . . . . . *Commander Phineas Bernstein* 164

Intestinal Injury and Fecal Fistula in Gynecological Surgery . *Henry C. Falk and Samuel Hochman* 176

Primary Treatment of War Amputations . . . . . *Major Elden C. Weckesser* 184

Internal Derangements of the Knee. Diagnosis and Treatment . . . *Major Bernard J. Mintz* 189

Roentgenologic Exploration of Sinus and Fistulous Tracts . . *Lieut. Col. Benjamin Copleman* 197

Refrigeration Anesthesia . . . . . *H. Ogle Horner* 201

Hypoproteinemia in Surgery of the Thorax . . . . *Martyn C. Ratzan and S. A. Thompson* 213

Use of Free Omental Grafts in the Thorax. An Experimental Study . . . . *Samuel Alcott Thompson and Boris Pollock* 227

Constant Traction Dressing . . . . . *Lieut. Comdr. W. James Gardner and V. B. Seitz* 232


## *Case Reports*


Benign Giant Cell Xanthoma of the Knee Joint . . . . . *Lieut. Comdr. Robert F. Foote and Captain Herbert C. Fett* 234

Postoperative Thrombosis of the Iliac Vein . . . . *C. C. McCorriston and C. M. Burgess* 237

Excision of the Elbow for Multiple Compound Comminuted Fractures . . . . *G. J. Curry* 243

Traumatic Brain Abscess and Meningitis. Cure Effected with Penicillin and Sulfadiazine . . . . . *Mark Albert Glaser and Mar W. McGregor* 249

Thrombosis of the Brachial Artery Treated with Successive Cervical Sympathetic Blocks . . . . . *Lieut. Col. Harwell Wilson* 255

Diverticulitis of the Vermiform Appendix . . . . . *W. A. Altemeier* 258

Reconstruction of the Common Duct with Vitallium Tubes . . . . . *A. V. Migliaccio* 261


## *Bookshelf Browsing*


Pre-Columbian Middle America Medicine . . . . . *R. J. Behan* 268


*General Information on Page 4* *Advertisng Index on 3rd cover*

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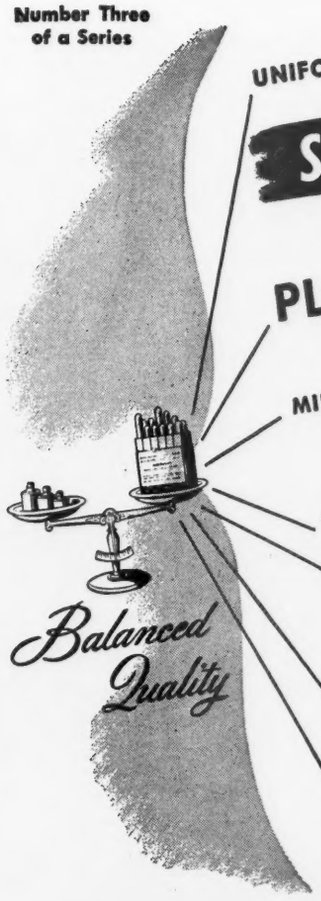


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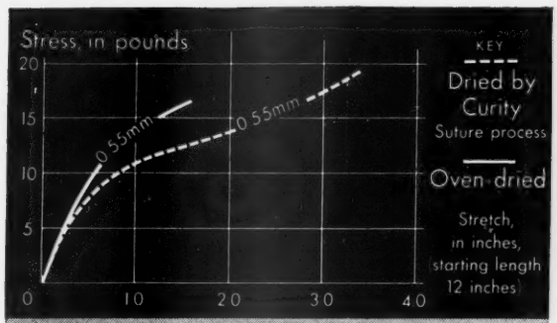


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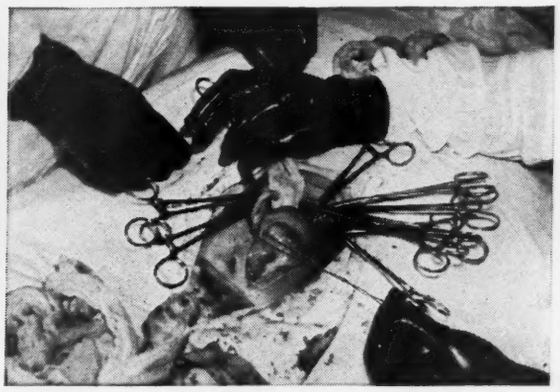

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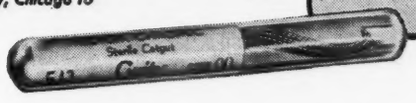

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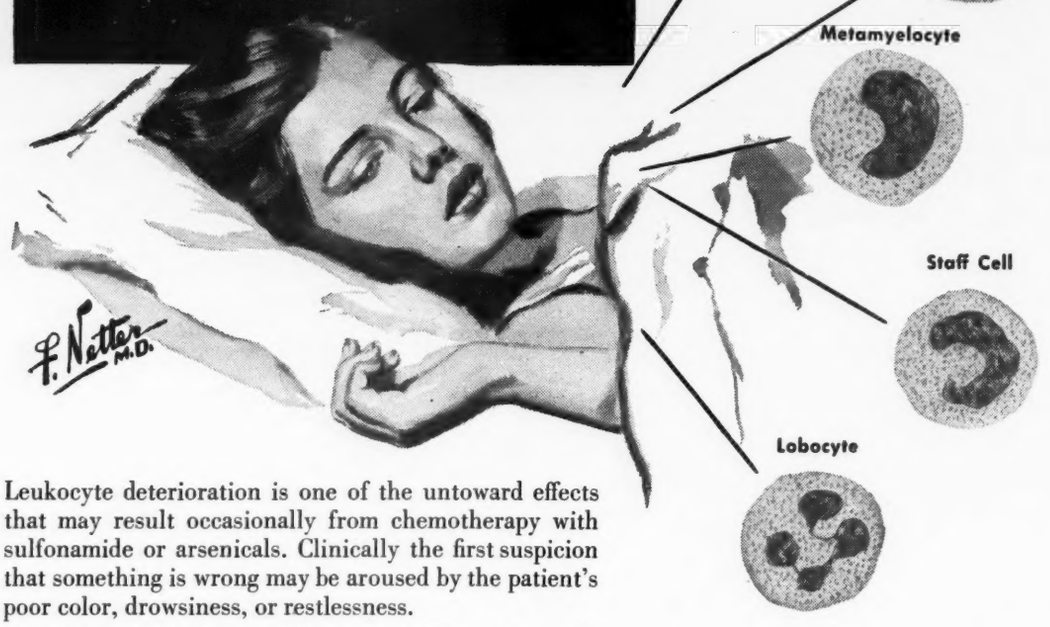


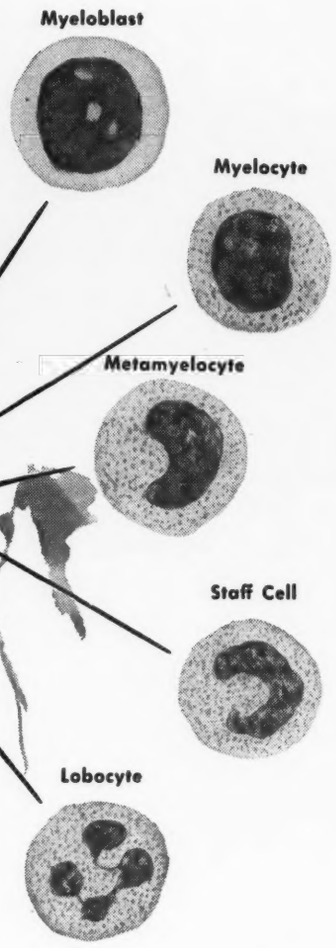


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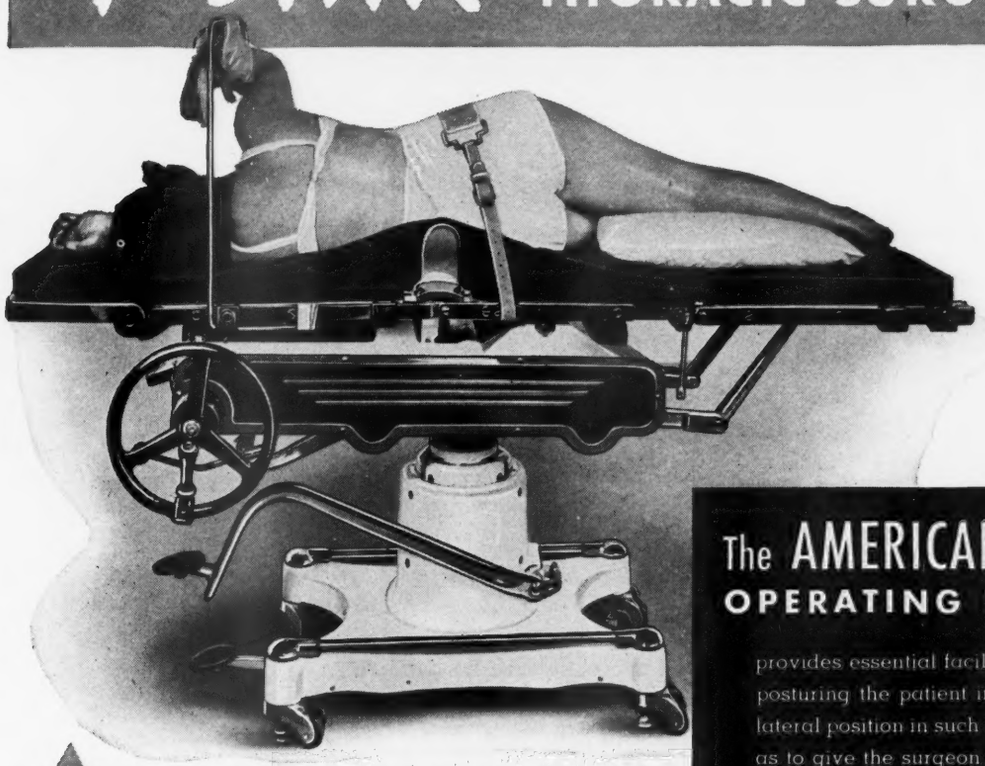

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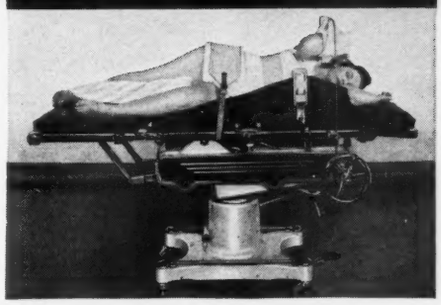

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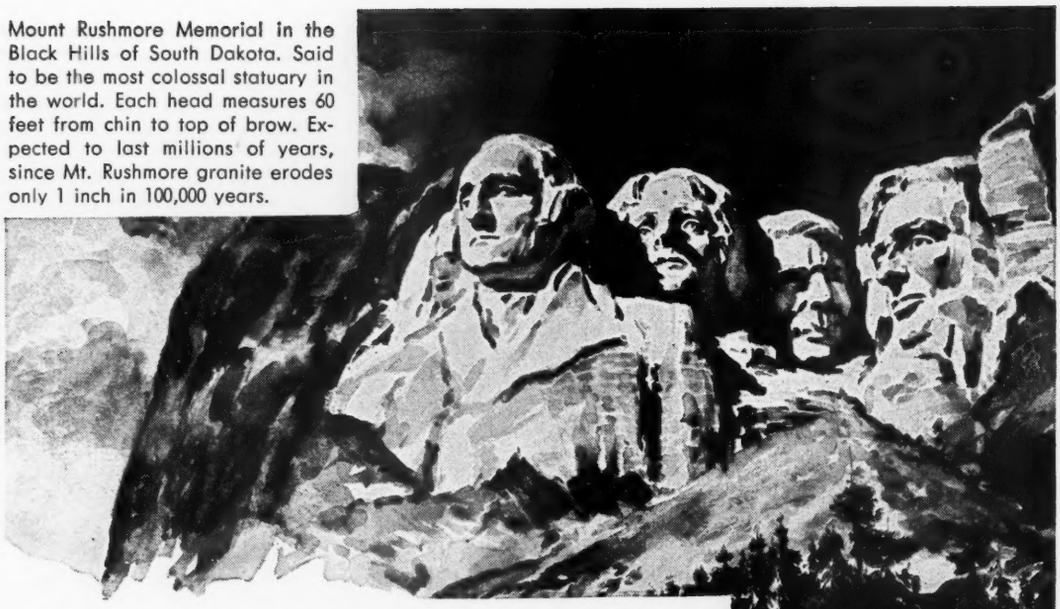

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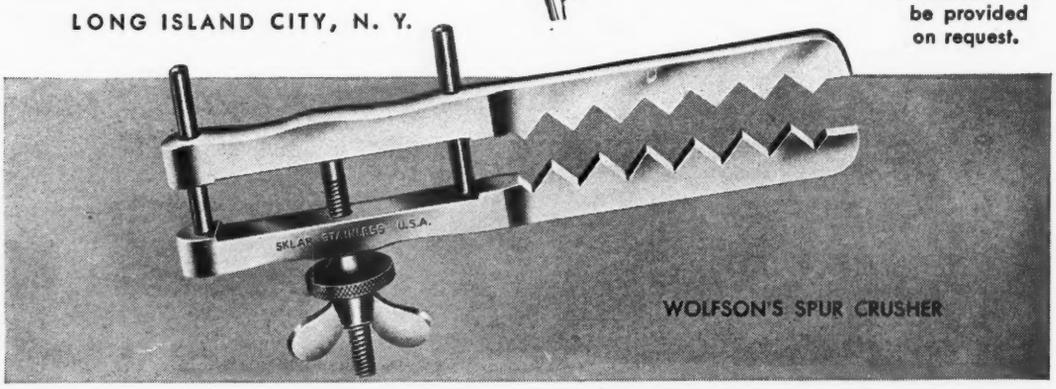


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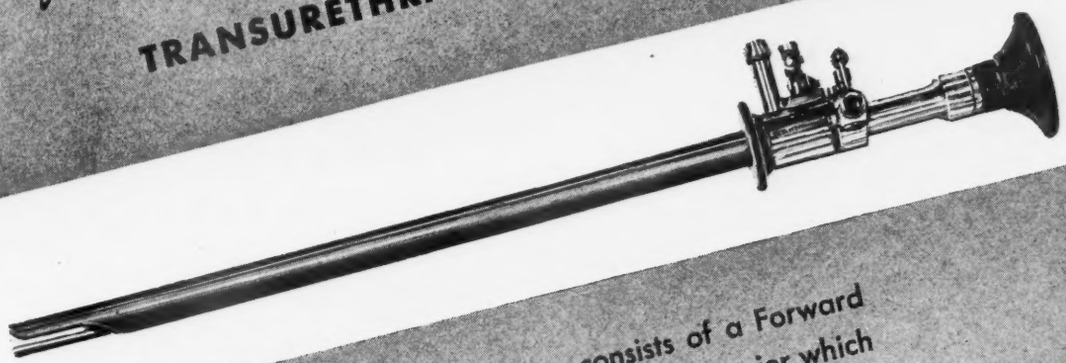
# The Vest Telescope

## *A New Inspection Lens System Useful in*

## TRANSURETHRAL RESECTION



This new inspection lens system consists of a Forward Vision Telescope and self-contained Light Carrier which is enclosed within an irrigating shield. (Illustration shows Vest Telescope locked in Electrotome sheath.) The users of the McCarthy Electrotome will appreciate the added utility of the Vest Telescope as a companion, supplementary instrument.

The lens system (forward vision) and light carrier extend to the end of the irrigating shield in which the telescope is enclosed. This irrigation shield in turn extends to the distil tip of the bakelite sheath when locked in position, and completely obliterates the fenestra. The Vest Telescope provides undistorted visual inspection of the posterior urethra, a view not possible to obtain with the foroblique system. Literature Available

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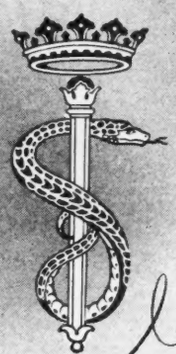

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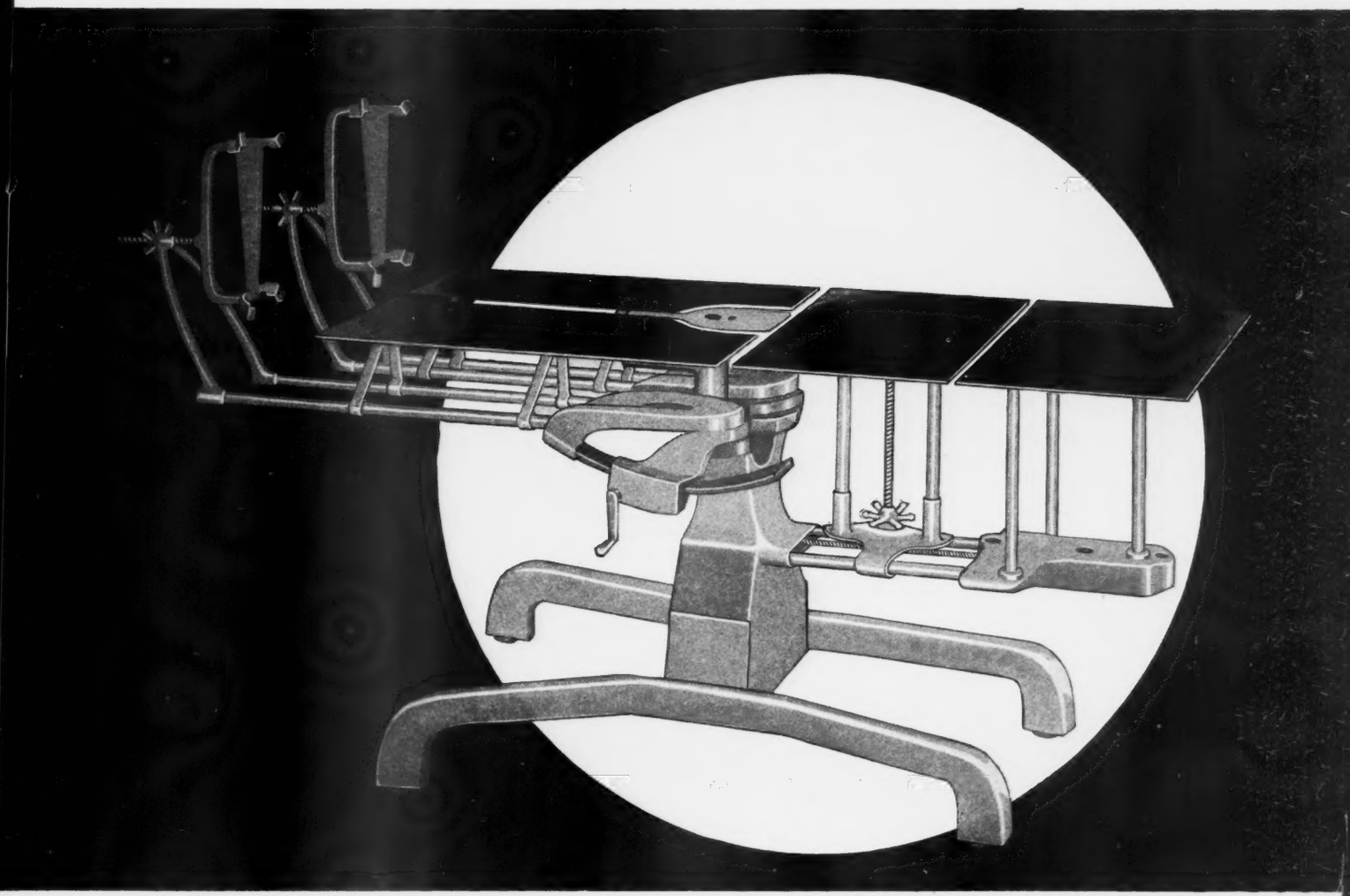

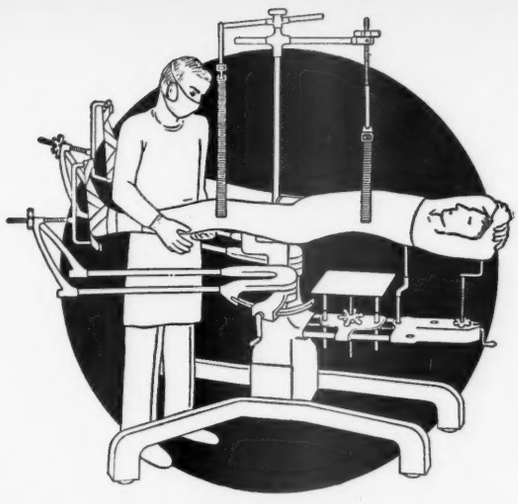

Application of a large double spica cast. The special occiput and interscapular supports are easily removable from body, shoulder or head casts.

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*Other notable advances.* Positioning in the true and reverse Trendelenburg, a transparent plastic perineal post, the quickly adjusted foot straps, special cassette holder for hip radiography, and unique head, face and shoulder supports.

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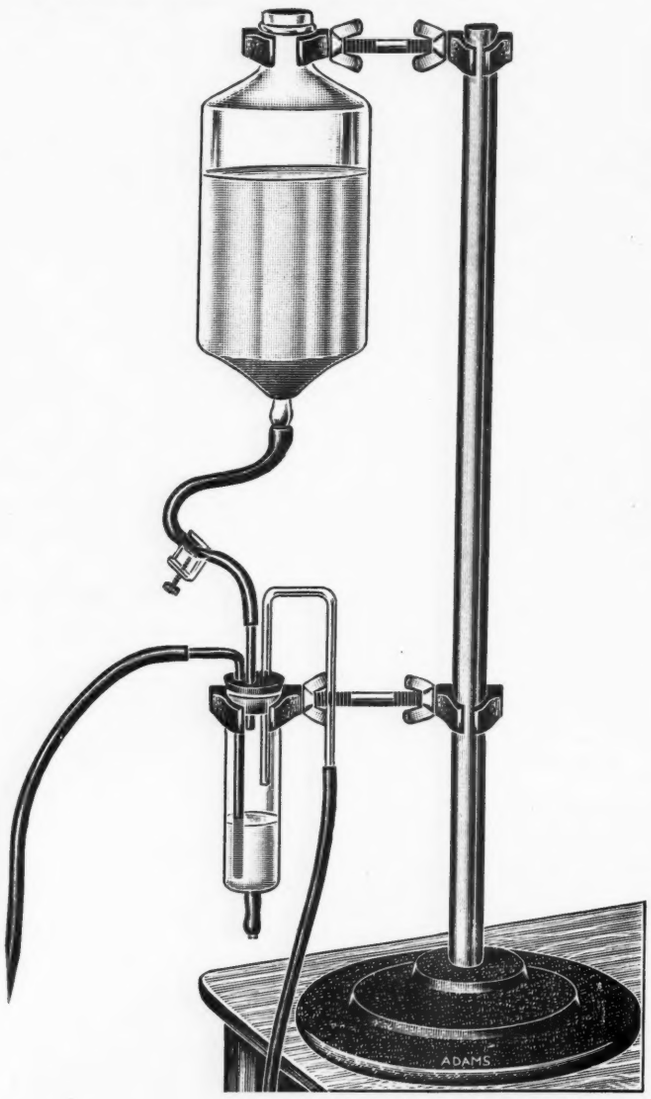
# RUPEL BLADDER IRRIGATOR

**as described by Ernest Rupel and Clyde G. Culbertson.**
**See Journal of Urology, Vol. 50, No. 4, October, 1943.**

***features . . .***

- **Completely automatic, employing simple physical principles for its operation**
- **Controlled frequency of irrigation**
- **Controlled volume of fluid per irrigation**
- **Simple to operate**
- **Requires a minimum of attention**




The Rupel Automatic Irrigator is an ingenious device that gives completely automatic tidal drainage to the urinary bladder. The frequency of irrigation together with a control of the volume of fluid per irrigation can be controlled readily by simple adjustment of the inflow clamp and adjustment of the height of the overflow control.

The apparatus is simple and entirely automatic. It is useful wherever an indwelling catheter is indicated. It requires little or no attention except to keep fluid in the supply flask on top and to keep the outflow jug empty.

The irrigating solution is allowed to drop slowly through the tubing into the overflow device. It passes out of the overflow through a longer tubing to the catheter and into the bladder. If the top of the overflow is placed at the level of the symphysis the fluid in the inverted U tube will gradually rise, indicating that there is a slight but increasing pressure in the bladder. With each breath, this column of fluid will rise and fall showing that the bladder is at complete rest. When the column reaches the top of the U tube, whether by pressure or because the patient has taken a deep breath, coughed or turned over the flow starts a syphonage that quickly empties the bladder. When it is empty, or if the overflow is too rapid for the return from the catheter, the syphonage pull simply lifts the valve in the tip of the overflow admitting air, thereby breaking the syphonage. The valve then settles back in place and the whole process starts again.

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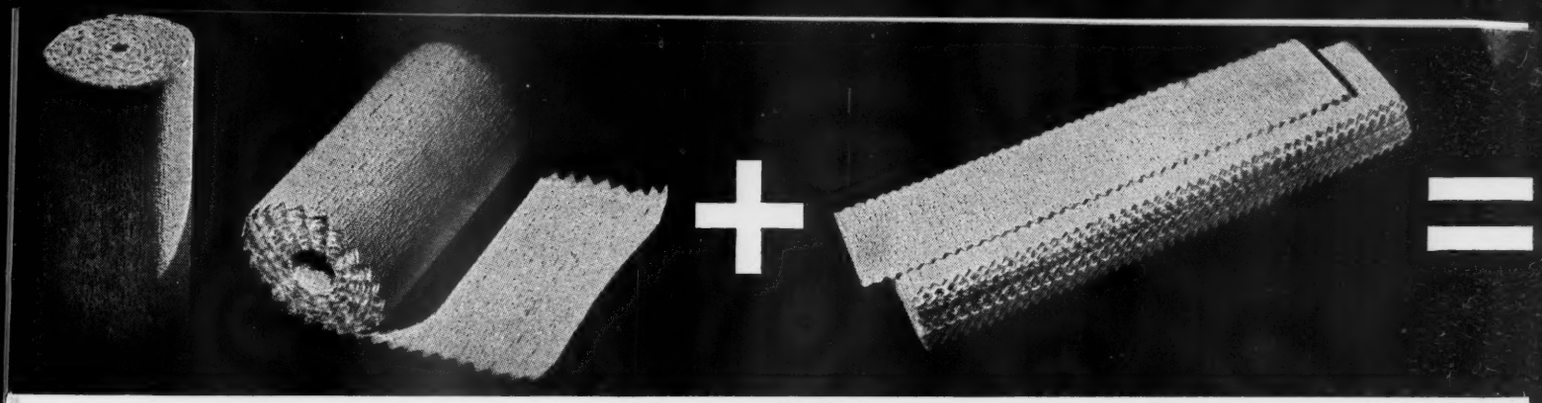
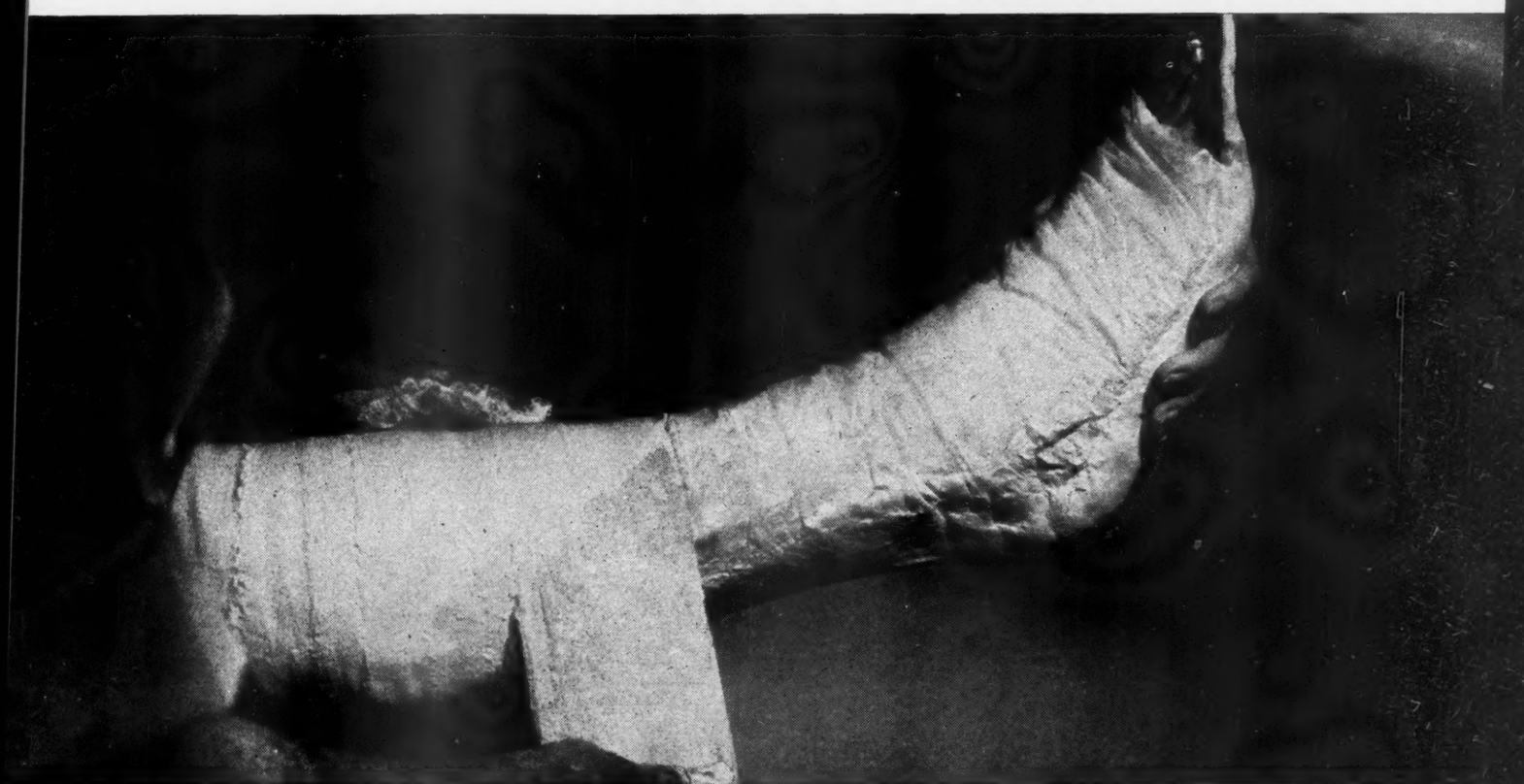


# Quick, versatile cast application!



• Build strong, light, dependable casts to meet all conditions. Save time. SPECIALIST* plaster-of-Paris Bandages and Splints may be applied separately, or in combination by using the ready-cut Splints as reinforcing slabs. This combination technique requires less material—casts are lighter, less cumbersome.

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Available clinical evidence indicates that Mol-Iron effects approximately:

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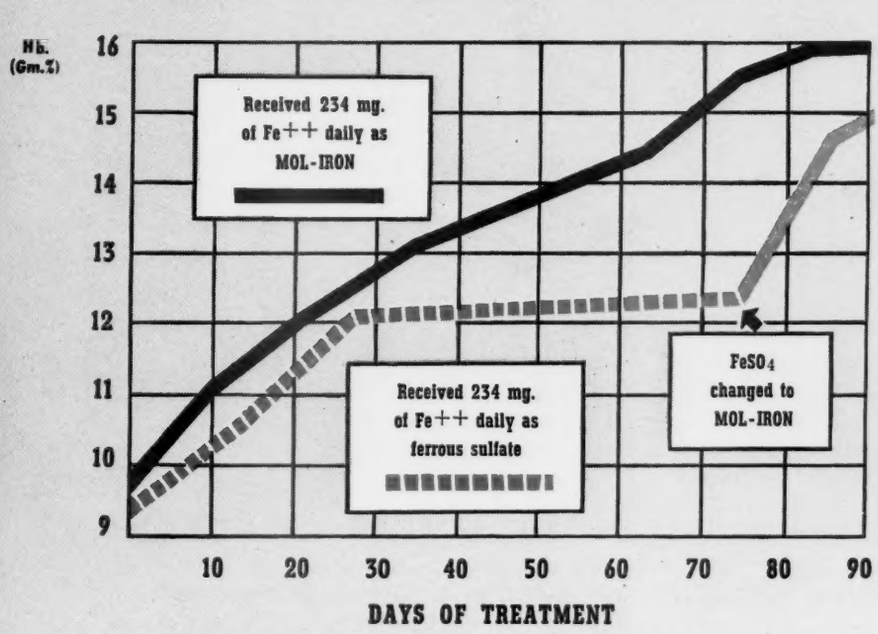
2. **100% MORE RAPID REGENERATION** of hemoglobin than does ferrous sulfate, with

3. **NOTABLE ABSENCE OF GASTRO-INTESTINAL REACTIONS**—even among patients exhibiting such untoward symptoms during administration of other commonly used iron preparations.

# TYPICAL HEMOGLOBIN RESPONSE TO MOL-IRON AND TO FERROUS SULFATE IN PREGNANT WOMEN WITH IRON-DEFICIENCY ANEMIAS




The therapeutically superior effect of Mol-Iron in human beings is well demonstrated in the accompanying graph which illustrates the rate of hemoglobin regeneration in females during the last half of pregnancy and having approximately the same degree of iron-deficiency anemia. Results in this series of cases are typical of those observed in an evaluation* of Mol-Iron in a series of pregnant women with hypochromic anemia.

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*Neary, E. R., Preliminary Evaluation of Molybdenum-Iron Complex in Hypochromic Anemias of Pregnancy, to be published.

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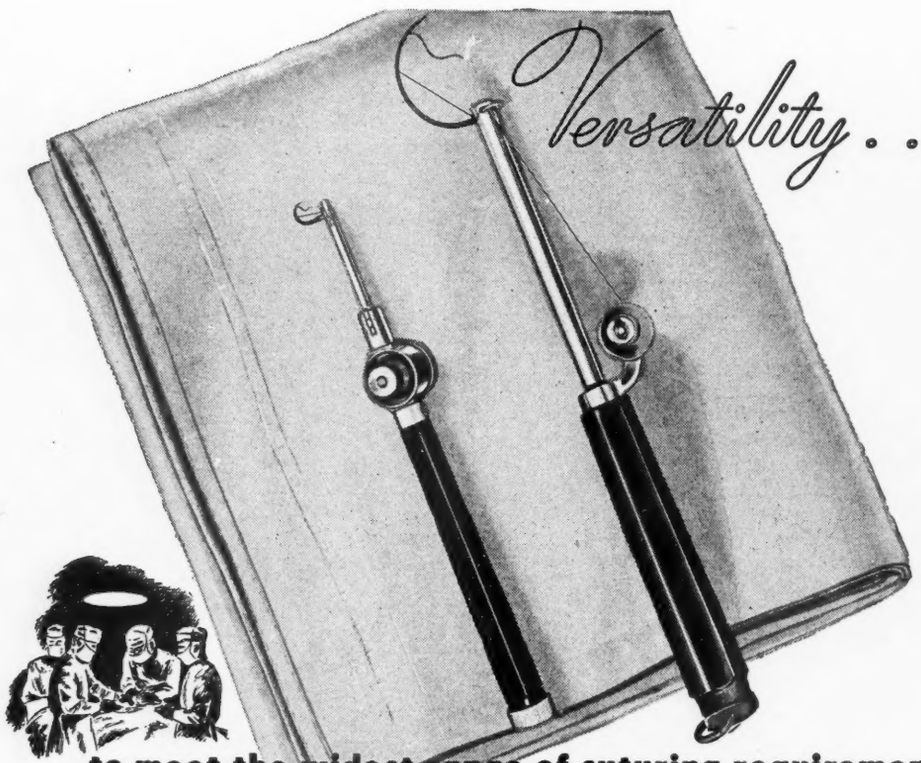

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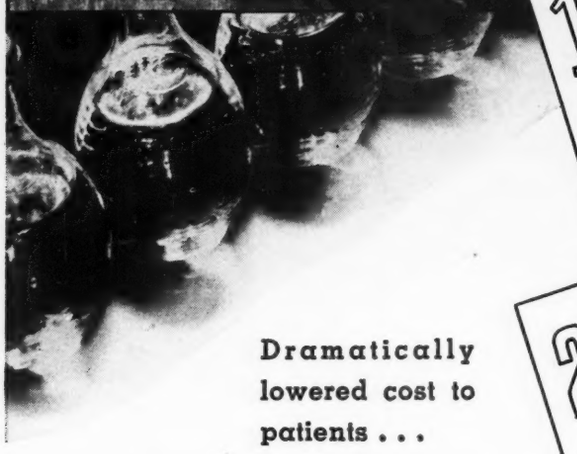

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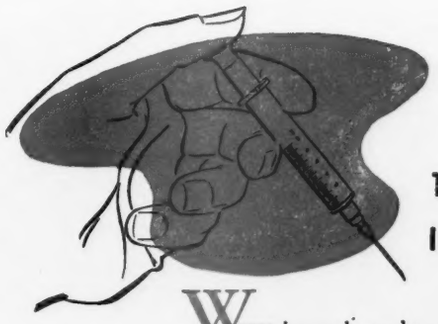

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*Rochberg, S.: *Anesth. & Analg.* 22:174, 1943.

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*Kramer, G. B., and Sedwitz, S.H.: Ceepryn: clinical and bacteriological studies, Am. J. Surg. 63:240-245 (1944)

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1. Int. Obst. Surg.; Supplement to Surg. Gynec. and Obstet.: 74:309 (April) 1942

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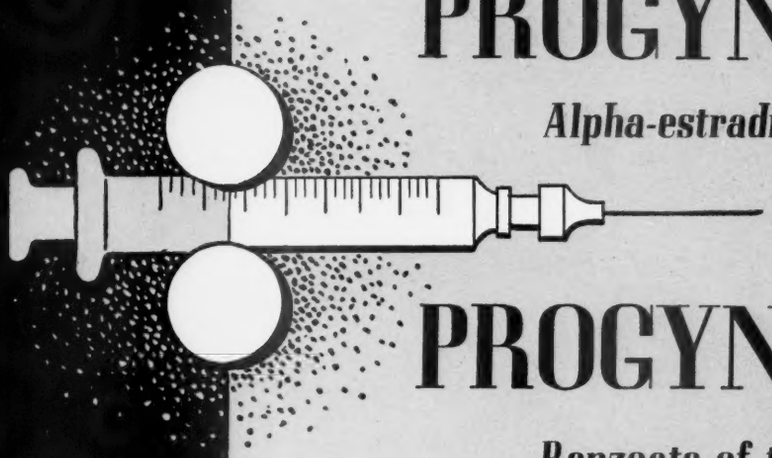

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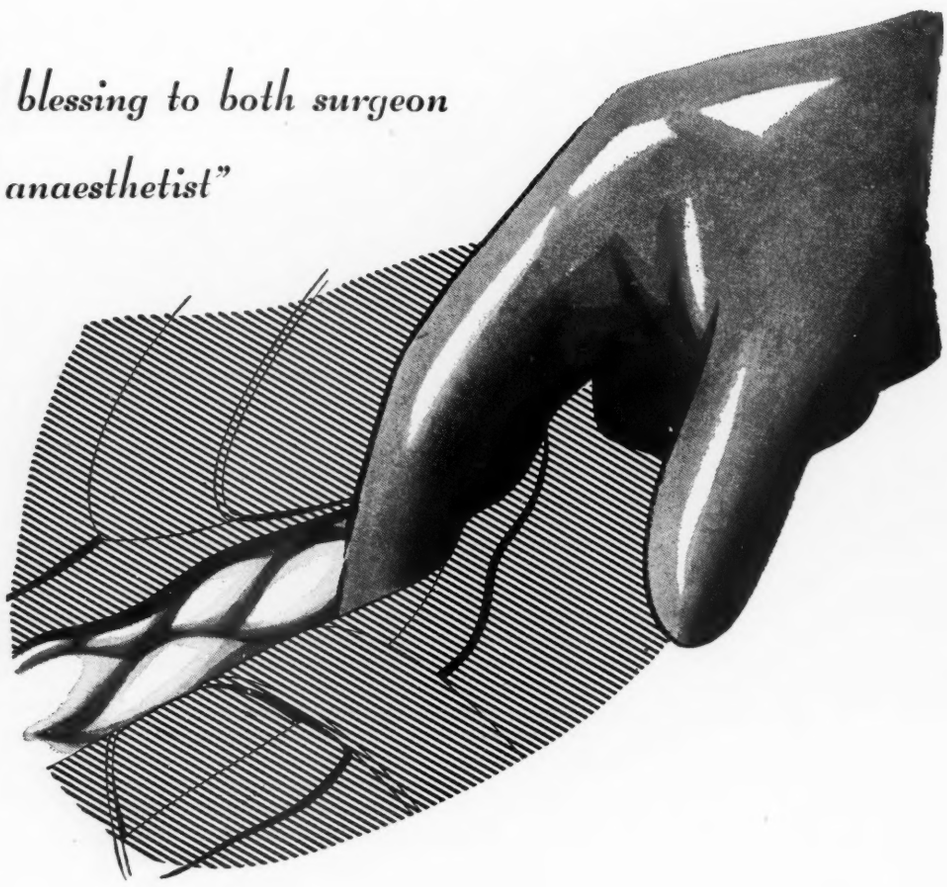
# *"A blessing to both surgeon and anaesthetist"*



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1. Griffiths, H. R.: Canadian M. Assn. J. **50**:144 1944.

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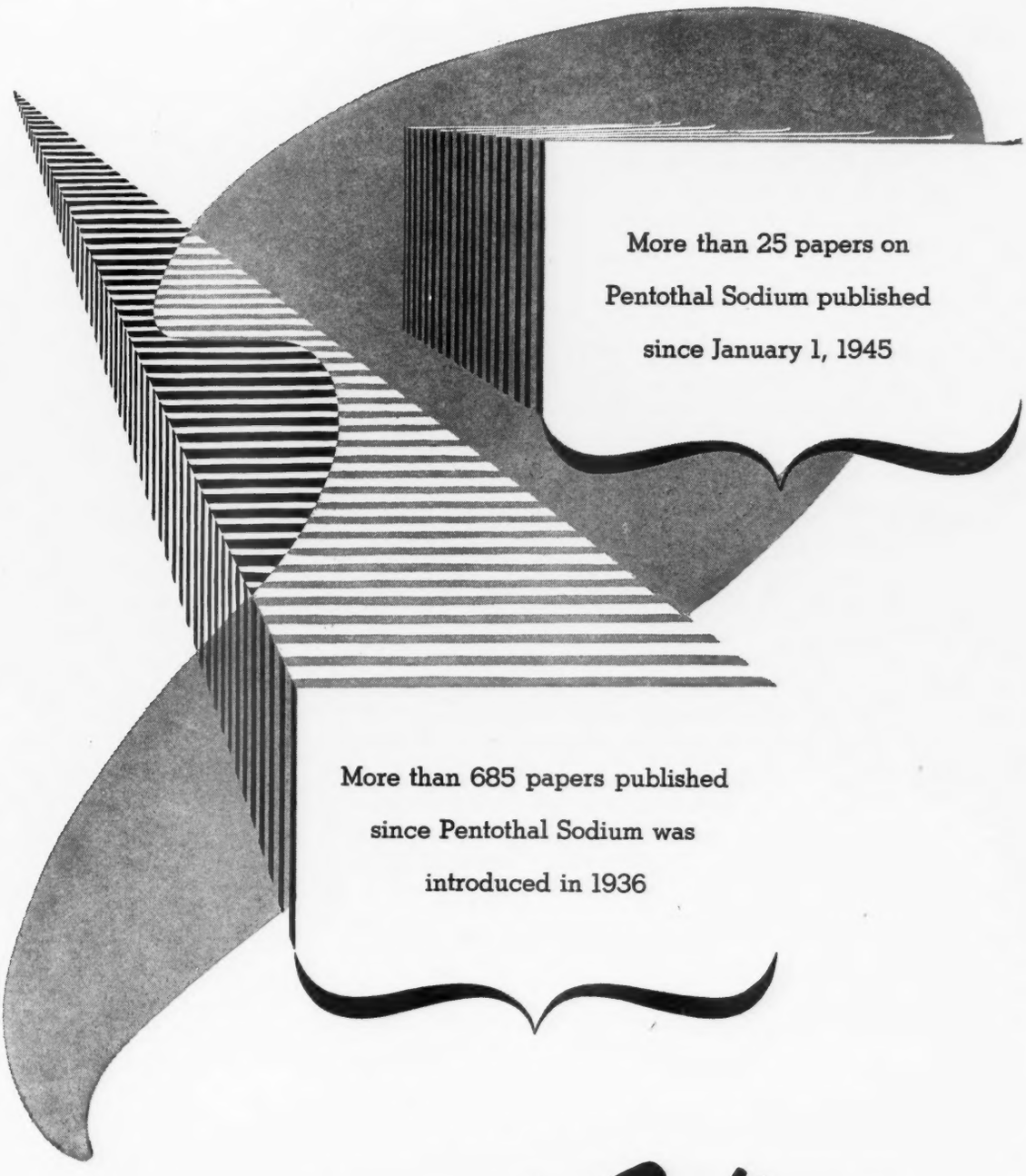
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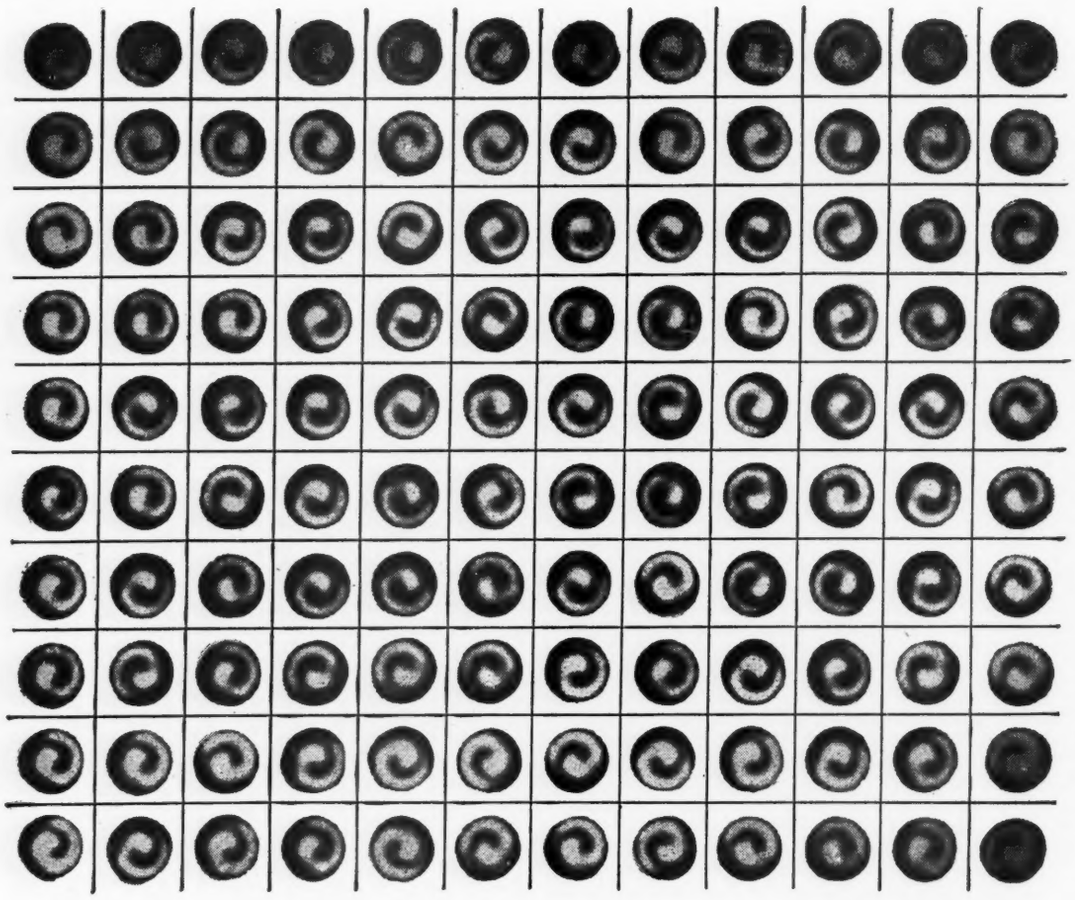

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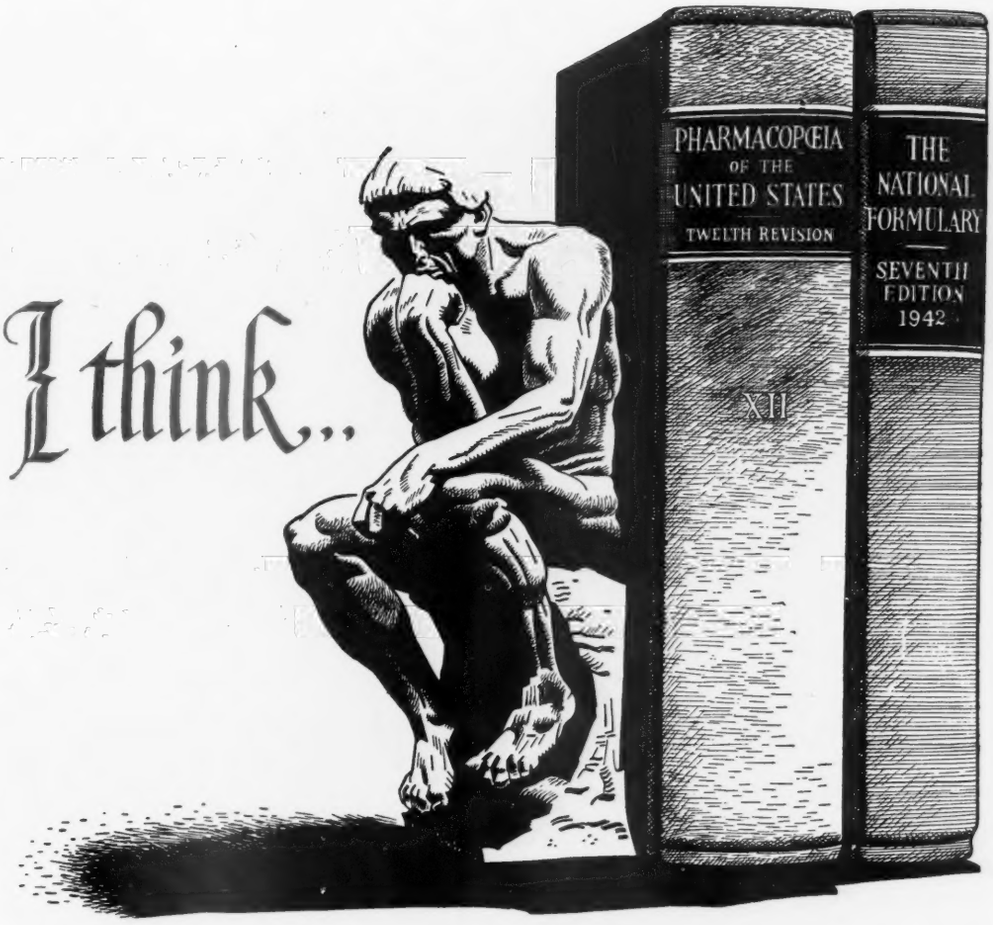


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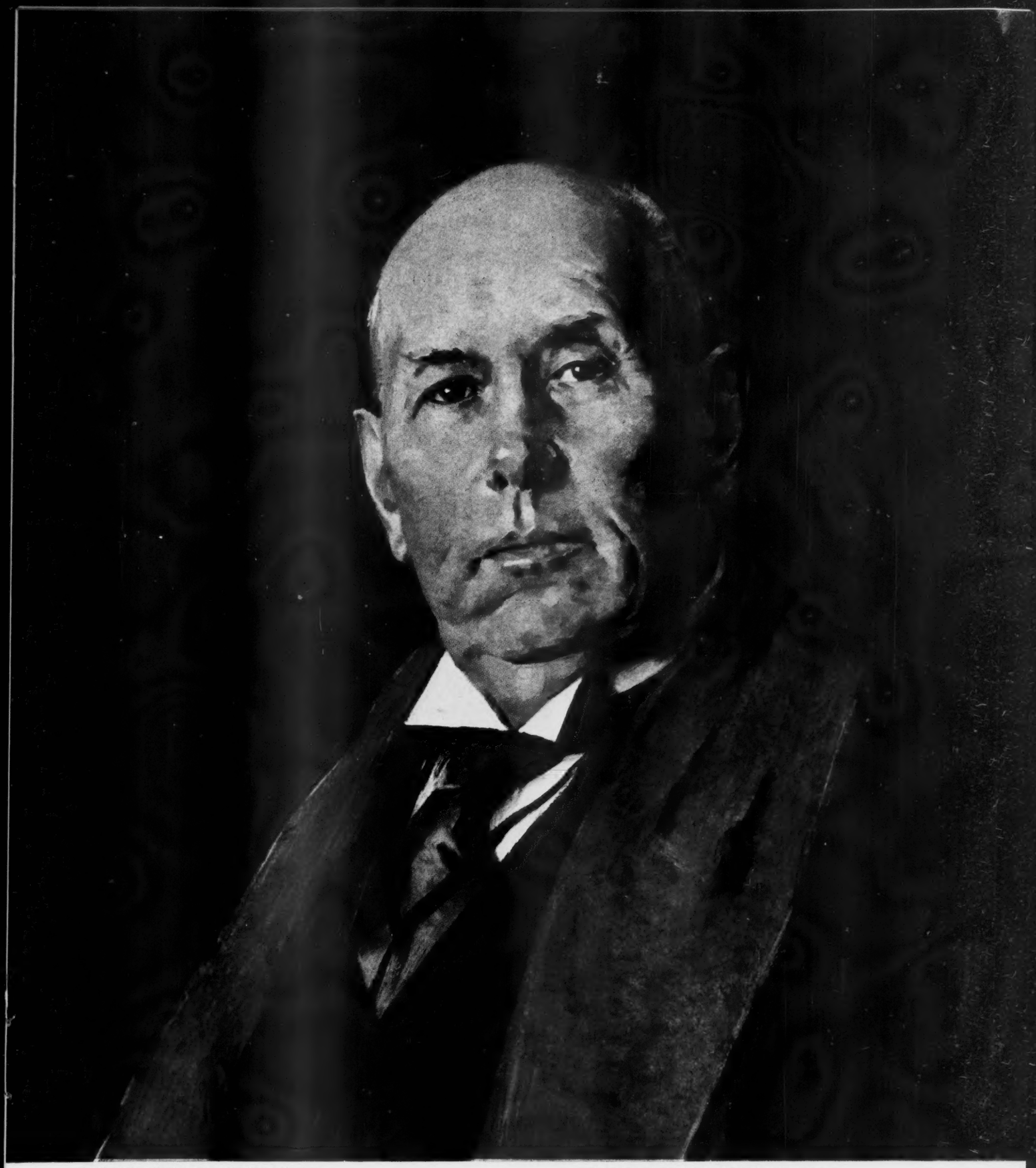

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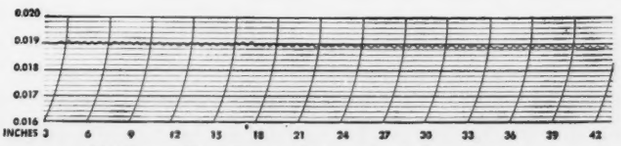


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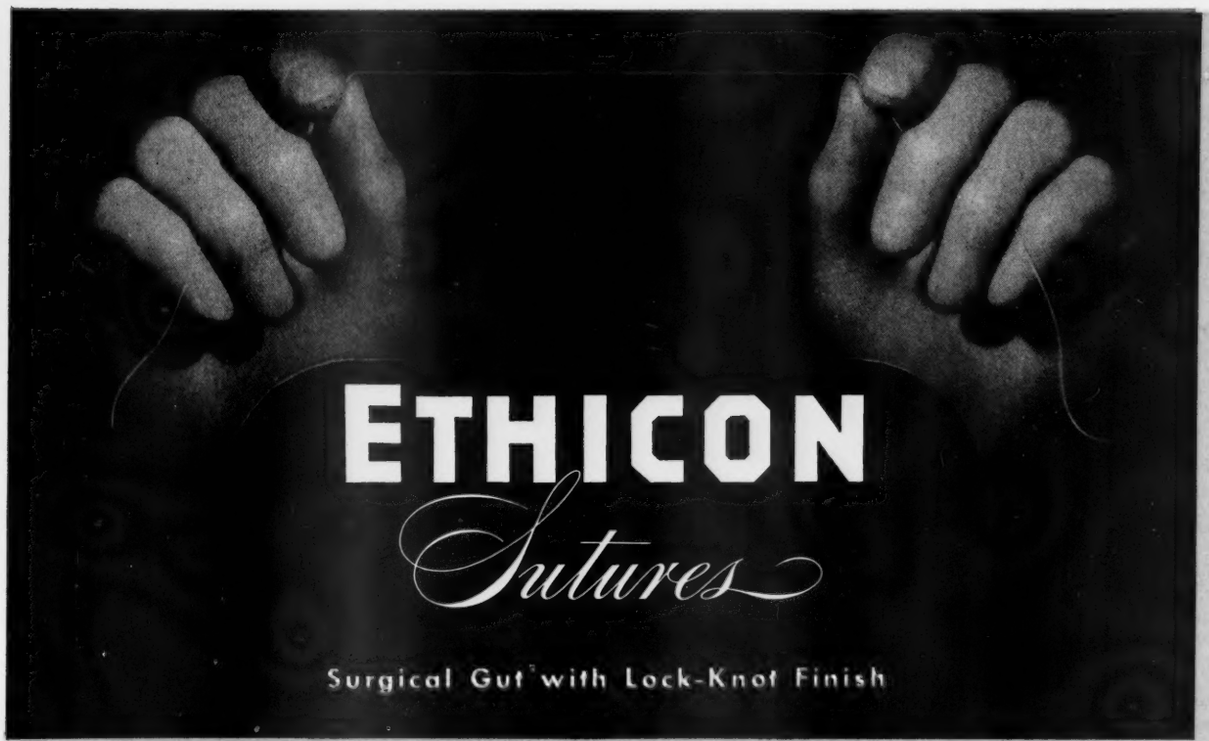

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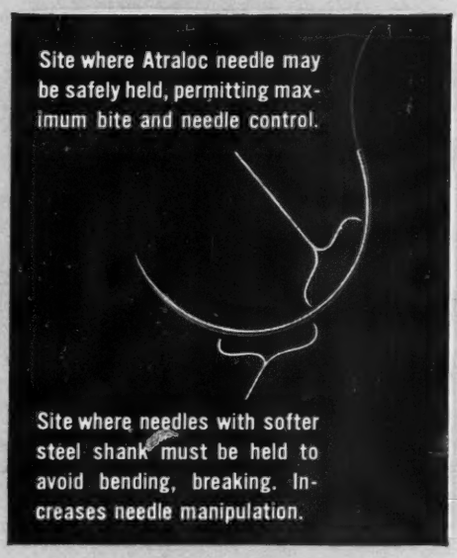
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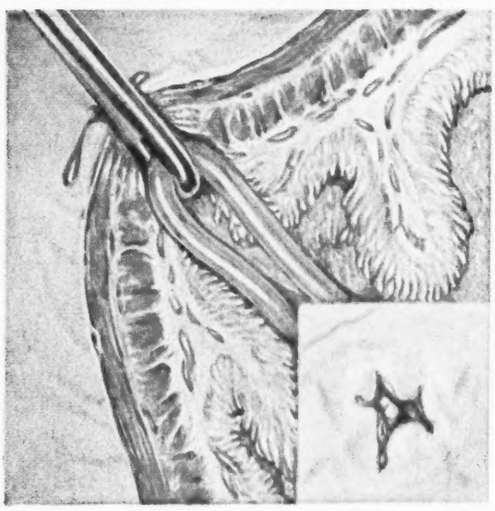

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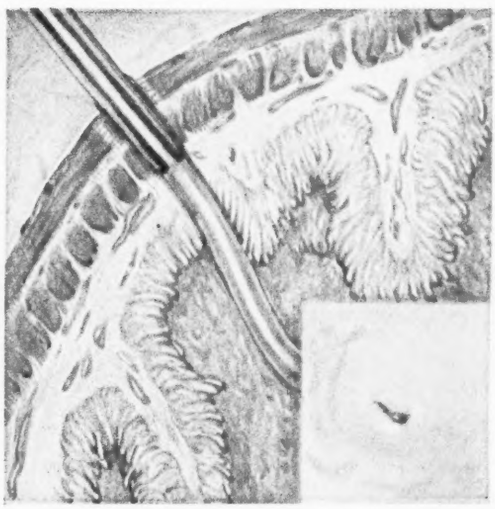

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NEW SERIES VOL. LXX NOVEMBER, 1945 NUMBER TWO

# Editorial

## SURGERY AFTER THE WAR

IT is interesting to deliberate the tendency and fate of medicine and particularly of surgery after this war. No one can foretell the future; but if experience in the practice of surgery for many years offers a clue, I may be in a position to hazard a guess. During a period of almost sixty years I have witnessed a veritable revolution in the progress of the art and science of surgery.

In 1887, when I served as a Militaer-Elève (Med. Sgt.) in the Garnisons-Spital in Prague it was my duty to wax linen threads, the sutures with which my commanding officer, Stabsarzt Strejcek, who regarded himself a modern surgeon, sewed up all fresh wounds washing neither his hands nor the wound. Of course they suppurated, all wounds did; that was considered normal healing (pus bonum et laudabile). Then came the spectacular era of Lister's antisepsis, and as an "Operations-Zoegling" in Prof. Billroth's and Guessenbauer's clinic it was with wonder that we witnessed healing of wounds by primary union. Then followed the greatest advance of all, the development of the technic avoiding bacterial infection, the marvelous era of asepsis which enabled us to perform even the formerly dreaded laparotomy with impunity. Every part of the human anatomy, including brain and spine and even the heart, was now successfully attacked by the surgeon. However, not only did operative technic show such progress but medical science and pathology as well became wide fields of study. The very fact that we could even for exploration open the abdomen and other parts *in vivo* without danger of infection afforded the surgeon the opportunity to observe pathologic changes in the living.

Medical history presents many illustrations of advance during periods of war. As early as the sixteenth century Ambrose Paré reintroduced the forgotten technic of ligation of blood vessels to stop bleeding in place of boiling oil or pitch. The Franco-Prussian war created many improvements in technic, among them the very important Essmarch tourniquet bandage. World War I found medicine and surgery, with a high standard Medical Corps, confronted with new problems which were met with startling new technics; and so it was that valuable contributions in plastic surgery were made. It will also be remembered that successful methods were developed to combat epidemic diseases—typhus, cholera and others—once rampant and now almost non-existent, a condition of immeasurable importance for an army. At the conclusion of the World War I began a feverish in-

terest and development of scientific activities, of international co-operation and exchange of methods. Doctors returned from their battle stations richly equipped with new experience and advanced methods. At this time the comparative values of standards of medicine and surgery could be observed in the family of nations.

Germany, hitherto judged as the most advanced nation scientifically, was superseded by others. The war had killed off her scientists and practicing surgeons in large numbers and those who were spared seemed to be affected with a sort of lethargy which did not allow them to continue the scientific effort of former times.

Instead of Germany, Great Britain and the United States developed a remarkable interest and enthusiasm for scientific work. This resulted in a predominance of progress in medicine in these countries and they became the most advanced stations of scientific life. All branches of biology were cultivated there, including medicine and surgery.

If we ask ourselves, what effect will this global war have on these two branches of science, we are convinced that Germany will be without any influence whatsoever; her scientists and surgeons are either dead or ethically and morally decadent owing to Hitler and his entourage. France, Austria and other European countries have suffered too much to have leisure and stability for science. It will remain, therefore, a privilege and pleasant duty of the victorious nations to carry and hold high the torch of science. Great Britain and Russia are capable, willing, even anxious to do it, and they certainly will when they have recovered from the wounds of the war; but the United States is the largest and the most promising country to come forward, free from ruin and devastation. We are for the present the most advantageously situated country as far as equipment and facilities are concerned and the most favored with men of attainment, ability and interest for advancement in science.

Surgery will of course be benefited greatly from this progress. The fact that a large number of doctors, who in peacetimes were not engaged principally in surgery but were forced to operate in the field, gained experience and skill is important. They will like to improve their practice, choose a specialty and increase the number of practitioners. There is room for all. The war caused many casualties and unfortunately there will be many more. Mortality is low but there will be many thousands who will require operative or orthopedic treatment. New ideas, new and radically improved methods, new and better instruments will be invented. Already one new feature seems to be preeminently stressed the restoration of functional capability of the disabled soldier by daily practical exercises even during his initial stay at the hospital. Adding to these new methods there are discoveries of drugs like the sulfa-compounds, penicillin and a host of others and last but not least the use of blood serum plasma in emergencies. All these new experiences will have to be scientifically checked, which will require an enormous activity in research life, the establishment of numerous new institutions of medical research. In fact we read already of the intention and plans of the health authorities to establish a large number of new hospitals. A very busy scientific life will follow the war and unquestionably medicine and surgery will profit considerably.

Carl Beck, M.D.

# Original Articles

## PILONIDAL DISEASE*

### MANAGEMENT OF CYSTS, SINUSES AND ABSCESSES IN NAVAL PERSONNEL

COMDR. EMIL GRANET AND CAPTAIN L. KRAEER FERGUSON
MEDICAL CORPS, UNITED STATES NAVAL RESERVE

AT our Naval Hospital 7.5 per cent of all operations on the surgical service in a recent period, were performed for the eradication of pilonidal inflammatory disease. According to the last available statistical report for the Medical Department of the United States Navy, 1941, pilonidal disease in the Navy and the Marine Corps accounted for 47,010 hospital sick days. From 1941 through 1943, the period coincident with the mobilization of our armed forces, thirty-two articles dealing with pilonidal disease were listed by the Index Medicus. These data indicate the magnitude of this problem, the adequate solution of which still challenges the medical corps of the Army and the Navy.

It is well established and universally accepted that the physical rigors and trauma associated with the military way of life ashore and afloat are direct factors in the activation of previously quiescent sacrococcygeal cysts and sinuses, to result eventually in pilonidal inflammatory disease and its sequelae. Study of recent publications leaves one with an accumulation of heterogeneous and conflicting information as to the best management of pilonidal disease, thereby affording little help to, and rather confusing the surgeon who is confronted with the problem of treating these patients.

It may be presumptuous to offer still another study on this well nigh exhausted subject. However, in analyzing our rather extensive material, especially those cases recurrent after previous operative "cure," certain errors in treatment and postoperative care become glaringly evident. Profiting by our mistakes and those of our colleagues, treatment of our most recent patients has resulted in a very consistent minimum morbidity in attaining anatomical and clinical cures.

Most recent authors agree that effective curative treatment of pilonidal inflammatory disease requires surgery. Numerous surgical procedures have been described. Most recent writers favor excision en bloc followed by some form of primary closure. When successful, this procedure results in a wound which heals rapidly and with minimal scar tissue. A number of able surgeons favor some form of partial closure with drainage, thereby insuring against the all too frequent infection of the primarily closed wound and the overlong morbidity resulting when this complication ensues. Limitation of space precludes a critical evaluation of the various published methods of treatment. Failures of these have come to us in the form of recurrent sinuses or incompletely healed wounds despite prolonged treatment. Excellent recent papers on this subject are those of Kooistra, Buie, DePrizio, Lane and others,[1–4] a careful study of which is essential for a comprehensive knowledge of the subject. In this study we intend to

* This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the U. S. Navy. The opinions and views set forth in this article are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

state our opinion as to the origin of pilonidal disease, to present a critical clinical analysis of a continuous series of 319 cases of inflammatory pilonidal disease treated surgically at our hospital and to describe the present method of treatment and management of these patients evolved from our experience.

Our problem—to return naval and marine personnel to full duty after one uninterrupted period of minimum hospitalization—is somewhat unique. In the case of acute pilonidal abscess for example, civilian and in some instances Army personnel stationed in camps with a post hospital are treated by simple incision and drainage. After a few days, they can be discharged to continue their work, or to light duty, returning at a later period—weeks or months—for surgical eradication of the disease in a now relatively quiescent state. Naval personnel, on the other hand, when transferred to hospital for treatment are expected to be returned to their ship or station with their wound completely healed and physically fit for full duty. Entirely quiescent lesions were not treated in this series as the present policy of the Navy Department, recently emphasized by Buie,[2] limits surgical treatment of pilonidal disease to symptomatic and inflammatory cases.

## ETIOLOGY AND PATHOLOGICAL PHYSIOLOGY

The official Navy term, cyst teratoma, inflamed or quiescent, sacrococcygeal, clinically and anatomically adequately describes the condition. The coined term, pilonidal (pilus: hair; nidus: nest) has become recognized through usage even though it is a misnomer as these cysts sometimes do not contain hair. Kooistra[1] presents evidence regarding the origin of sacrococcygeal cysts and sinuses which to our mind concurs with clinical and pathological findings. In a study of forty human embryos, he found a remnant of the neurogenic medullary canal overlying the coccyx in all. In the larger embryos, this invariably assumed the character of a cyst-like space lined by cells and as a rule, well separated from the skin. During the second half of fetal life these cyst-like structures were seen to undergo gradual atrophy becoming not only smaller in size, but also showing a tendency to be replaced by connective tissue. Kooistra also found evidence favoring a second theory. He found in some embryos, defects in the surface epithelium with marked irregularity, some showing actual invagination to form deep dimples. This latter description is in accord with the findings of Fox[5] in his exhaustive study of the subject.

According to these embryological studies the medullary (neurogenic) origin should be represented clinically by subcutaneous sacrococcygeal cysts which have no demonstrable sinus leading to the skin surface. On the other hand, pilonidal disease originating in the embryo by infolding of the epidermis occurs clinically as a sacrococcygeal dimple or sinus. Both anomalies frequently are concurrent so that contiguous cysts and sinuses are common clinically. Three types of chronic pilonidal disease seen clinically are the following: (1) Sacrococcygeal cyst, alone; (2) sacrococcygeal dimple or sinus, single or multiple, alone; (3) sacrococcygeal cyst adjacent to or communicating with one or more sinuses.

It is commonly accepted that hair found in pilonidal cysts and sinuses grows from the epithelial lining thereof. Our clinical and pathological observations refute this view. We have never found hair in a solitary pilonidal cyst (type 1 above). Hair was found only when the cyst was found to communicate with an adjacent sinus, in sinuses, and in deep dimples. Lane[4] carefully studied sections from forty-two cases of pilonidal disease. In the few cases in which fragments of epithelial tissue survived the destructive effects of infection, no sebaceous sweat glands or hair follicles could be found in any of his sections. We have yet to see undoubted evidence of hair follicle structure in sections taken through the wall of excised

pilonidal cysts. Sections through the hair itself lying free in the lumen or on the cyst wall are seen. Nor have published microphotographs presumably illustrating hair follicles in the wall of excised pilonidal cysts satisfied the histologic criteria of a true hair follicle. What has usually been illustrated is a cross-section through an actual hair. (Theis Fig. 3B–"H.")[6] Furthermore, if the neurogenic theory as to the origin of the solitary pilonidal cyst is accepted, it is difficult to explain in these the presence of epidermal structures such as hair follicles. At operation when strands of hair were found, they always lay free and unattached in the cyst or sinus cavity. It is our conviction that this hair is extraneous having its origin in the hair follicles of the skin of the natal fold adjacent to the sinus or dimple. Individual strands of hair originating in the external skin protrude and advance into the congenital sinus and even into the contiguous cyst. Eventually, through the trauma of constant friction between the skin surfaces in this region, some of the protruding hairs are broken off near their root and are retained in the sinus or cyst. Through years of accumulation and by constant moulding from external mechanical pressure, they eventually become compressed and kneaded into so-called hair "nests."

Normally quiescent pilonidal cysts and sinuses when exposed to oft repeated trauma eventually become painful, tender, and infected. The constant presence of pathogenic micro-organisms on the skin of the coccygeal region are prime etiological factors in the pathogenesis of these lesions. The rôle of trauma is illustrated by the universal habit of sailors who constantly sit on hard decks, knees drawn up, shoulders braced against the bulkhead and the entire weight of their bodies rolling back and forth on the sacrococcygeal area synchronous with the motion of the ship. Falls on deck and down ships' ladders are common and contribute to the marked prevalence of pilonidal inflammatory disease in the Navy.

## CLINICAL MATERIAL

At our Naval Hospital in the twenty-month period from April, 1943, through November, 1944, 319 patients were operated upon for the eradication of pilonidal inflammatory disease. Incision of abscesses and other palliative measures were not included in this series. The earlier cases in this series, Group I, were assigned to the general surgical service and were treated by twenty-six different surgeons, inasmuch as changes in staff are frequently necessary in military hospitals. Diverse technics of operation, various suture materials and individual routines of postoperative management were employed in this series. These cases, therefore, afforded us a cross-section of the end results attained by the average surgeon in his treatment of inflammatory pilonidal disease. The average hospital time required for cure, as determined by complete epithelialization of the wound, was found to be prolonged in this group. It was apparent that some standardization of procedure was essential in order to obtain optimum reduction of healing time. Patients treated in the last eight-months period, Group II, were, therefore, assigned to one surgical ward under the care of one of us (G.). Standardization of treatment, to be described, resulted in substantially reduced sick days as compared to Group I.

Inasmuch as pilonidal inflammatory disease occurs clinically in various forms, intelligent treatment of necessity must differ for each type of lesion and is dependent on the extent and nature of the inflammatory reaction in the individual case. For practical purposes we found it expedient to describe our material as (1) primary cases, those patients who had no previous definitive surgical treatment, and (2) recurrent cases,—those patients with recurrent lesions and symptoms following previously unsuccessful, definitive operative treatment. Of 319 cases in this series, 241 (75 per cent) were *primary* and seventy-eight (25 per cent) were *recurrent* according to this classification.

PRIMARY CASES

Table 1 represents the types of lesions encountered and the average duration of symptoms, for each type, prior to admission. Acute pilonidal abscesses, 29 per cent, were seen within a few days after onset of pain, the usual chief subjective symptom in this group. Chronic draining sinuses alone, 34 per cent, and chronic sinuses associated with chronic cystic abscesses, 26 per cent, were usually symptomatic for months and when examined after excision were found to contain nests of hair almost without exception. On the other hand, chronic subcutaneous cysts alone, 9 per cent, with no demonstrable adjacent dimple or sinus contained chronic inflammatory granulation tissue, occasionally associated with mucoid pus, but in no such instance could hair be found within the lumen after excision. Everted coccyx was associated with pilonidal cystic disease in four patients who complained of pain. At operation the everted portion of the coccyx was removed with the cyst.

TABLE 1
TYPES OF INFLAMMATORY LESION AND DURATION OF SYMPTOMS IN 241 CASES OF PRIMARY PILONIDAL DISEASE

| Lesion | No. | Per Cent | Average Duration of Symptoms |
|---|---|---|---|
| Sinus | 83 | 34.5 | 6 mo. |
| Acute abscess | 69 | 28.7 | 4 da. |
| Infected cyst and sinus | 64 | 26.5 | 8 mo. |
| Infected subcutaneous cyst | 21 | 8.7 | 4 mo. |
| Cyst and everted coccyx | 4 | 1.6 | 1 mo. |

RECURRENT CASES

As stated, pilonidal disease recurred after operation in seventy-eight (25 per cent) following one or more attempts to attain surgical cure. For a condition readily remediable by a simple surgical procedure, this recurrence rate seems enormous. (Table 11.) Operation in about one-third of this group was done in civilian hospitals prior to enlistment. Of great interest is the fact that two-thirds of the group in whom the type of previous operation could be determined had had some form of primary closure. In most of sixteen patients who had previously had some form of open operation, re-admission to the hospital was necessitated by failure of the wound to remain permanently healed following an unsuccessful trial at duty.

TABLE 11
RECURRENCES AFTER PREVIOUS OPERATIONS—SEVENTY-EIGHT CASES

| No. of Previous Operations | Cases | Lesion | | |
|---|---|---|---|---|
| | | Sinuses | Abscess and Sinus | Abscess |
| 5 | 2 | 2 | | |
| 4 | 1 | 1 | | |
| 3 | 3 | 3 | | |
| 2 | 14 | 11 | | 3 |
| 1 | 58 | 49 | 5 | 4 |
| Total | 78 | 66 | 5 | 7 |

| Previous Operations | Naval Hospital | Civilian Hospital | Civilian and Naval | Army Hospital |
|---|---|---|---|---|
| | 48 | 24 | 4 | 2 |

| Type of Previous Operations | Primary Closure | Open or Partial Closure | No Information Obtainable |
|---|---|---|---|
| | 43 | 16 | 19 |

This recurrence rate of 25 per cent in patients operated upon in various sections of the country by both military and civilian surgeons is excessive. It indicates that too few surgeons are sufficiently familiar with fundamental anatomic, pathologic and physiologic features of this problem, a clear concept of which is essential to attain satisfactory cures in this disease. Furthermore when it is noted that two-thirds of our recurrent cases followed attempts at primary closure, our criticism becomes more tangible. In the literature

recurrence is generally attributed to the fact that some portion of sinus tract remained in the wound due to incomplete currence inasmuch as surgeons are generally cognizant of this pitfall in technic and are extremely careful to remove completely

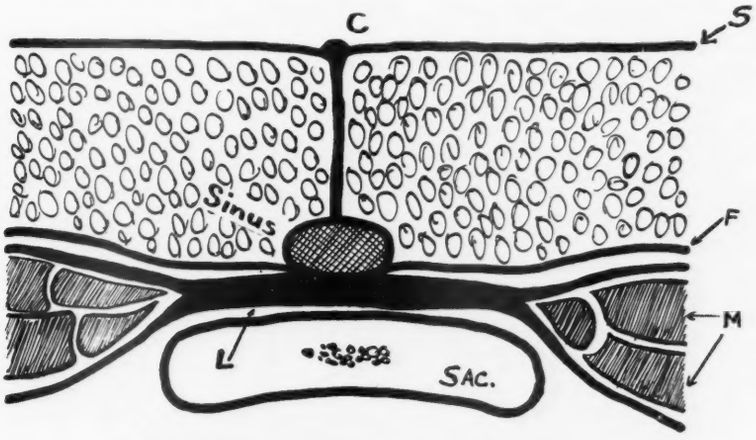


FIG. 1.

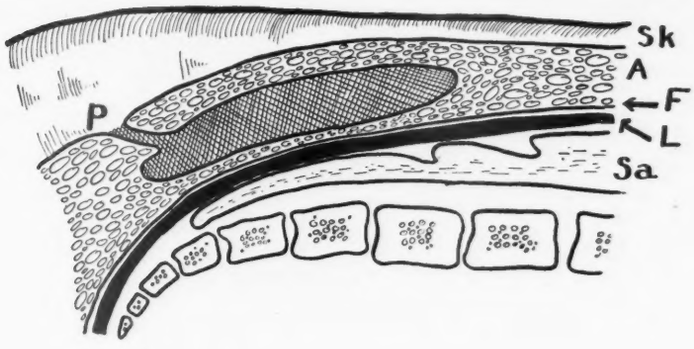


FIG. 2.

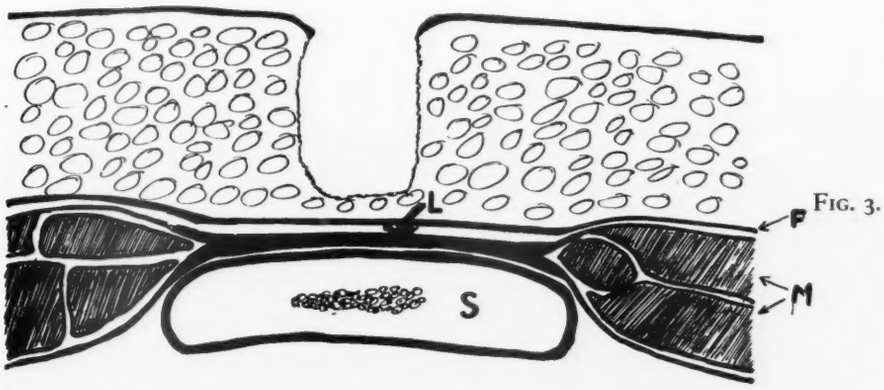


FIG. 3.

FIG. 1. Deep sinus recurrent following unsuccessful primary closure. C, cicatrix; S, skin; F, postsacral fascia; M, gluteus maximus muscle; L, posterior sacrococcygeal ligament.

FIG. 2. Sagital section through a pilonidal cyst and sinus with related anatomical structures. P, cyst and sinus; SK, skin; A, areolar fat; F, postsacral fascia; L, posterior sacrococcygeal ligament; SA, sacrum.

FIG. 3. Transverse section following removal of cyst and sinus in a case favorable for primary closure. F, postsacral fascia; L, posterior sacrococcygeal ligament; M, gluteus maximus muscle.

removal and subsequently this acted as a nidus for reactivation of the infection. This factor is probably of infrequent occurrence inasmuch as surgeons are generally cognizant of this pitfall in technic and are extremely careful to remove completely all sinus tracts. We are in full accord with DePrizio's statement[3] that, "pilonidal cysts and sinuses when treated by radical sur-

gery do not recur as such. At secondary operation one seldom finds encysted material."

In most of our cases recurrent after unsuccessful primary suture we were impressed with the uniformity of the secondary lesion as to location and type of condition. In these patients well healed scars were found over the sacrococcygeal region. Typically at the distal extremity of said scar, deep in the natal fold, a draining sinus opening was found. Through this opening a probe could be passed into the sinus which extended cephalad deeply under the scar and directly over the sacrum. At secondary operation the healed cicatrix, formed by the previous approximation of subcutaneous areolar tissue and skin, was divided to expose a deep sinus tract containing friable, violatious, chronic granulation tissue. (Fig. 1.)

Failure of permanent healing occurring with such uniformity must result from a fundamental error in surgical fabrication. That these poor results were not due essentially to defects in individual technic is shown by the fact, previously mentioned, that these forty-three wounds were primarily sutured by as many different surgeons in many parts of the country, presumably with a variety of individual methods and suture material. Furthermore, in many cases, recurrence took place many months after operation, some after one or two years. Remarkably enough, only the deepest portion of the repair, the region directly overriding the sacrum and coccyx, broke down. The skin and subcutaneous tissue which formerly was the seat of the bulk of the pilonidal disease remained firmly healed, the defect left by excision having been replaced by a firm, mobile, well healed scar. In a few exceptional cases, a secondary sinus opening penetrated the proximal portion of the scar.

To our mind the uniformity of the lesion found in our recurrent cases suggests the fact that the original surgeon disregarded fundamental factors in the repair of surgical wounds. That wound infection is not the chief factor is shown by the fact that perfect healing took place in the subcutaneous tissues and that breakdown of the wound most often occurred months after operation and apparent cure. In reviewing much of the literature on the treatment of pilonidal disease by primary suture, it is obvious that most authors are not clear in their concept of the significant anatomy of the region. To elucidate, most writers describe the removal of the cyst and all possible secondary sinuses, "down to the sacral fascia." The impression is given that the postsacral fascia and the posterior sacrococcygeal ligament are analogous. This is far from true. (Figs. 2 and 3.)

Actually the postsacral fascia delimits the ventral extent of the very vascular, loose, fatty, areolar subcutaneous tissue to which this thin but firm, fibrous, fascial membrane is very intimately attached. A potential space separates the post-sacral fascia from the posterior sacrococcygeal ligament as demonstrated by the relative mobility of the fascia on the ligament when this tissue is exposed at operation. The posterior sacrococcygeal ligament on the other hand, consists of a firm, tendinous, shiny, relatively avascular ligamentous structure intimately attached to the periosteum of the sacrum and coccyx and confluent with the fascia of the gluteal muscles laterally. (Figs. 1, 2 and 3.) The distinction between fascia and ligament must be clearly understood as thereby lies the key to successful primary closure.

In dissecting the cysts and sinuses "down to the sacral fascia," it is probable that many surgeons unknowingly carry their dissection through the postsacral fascia thereby exposing the posterior sacrococcygeal ligament. They then proceed with an accurate closure taking care to avoid dead space and tension on the suture line. A sutured wound results presumably with accurate approximation of tissue in layers in the following arrangement: (1) skin to skin, (2) areolar tissue to areolar tissue and (3) areolar tissue and fascia to

posterior sacrococcygeal ligament. It is a well established physiological fact that healing of sutured wounds per primum is dependent upon a rich vascular bed in both approximated tissues. These criteria are satisfied in both the skin and subcutaneous areolar tissues in the sacral region so that excellent healing was expected and was in fact universally present in these tissues. However, it is physiologically unsound to expect firm union when richly vascular, fatty areolar tissue is approximated to posterior sacrococcygeal ligament, a tendinous, fibrous and practically avascular structure. A similar situation and principles apply to repair of inguinal hernia as pointed out by Seelig, by Joyce and by Gallie and Le Mesurier[7] who state that, "side-to-side suture of muscle (vascular) as in the suture of the internal oblique muscle to Poupart's ligament (avascular) results in union of practically no strength." Relative healing time is another factor to be considered in this connection. Firm healing of tissues (1) and (2) above, requires about ten days. One cannot reasonably expect strong union between areolar tissue and ligament, (3), in this short time. With resumption of normal activity by the patient rigid fixation of the suture line is disturbed resulting in potential disruption of union and possibility of development of a dead space.

Infection is another factor tending to disrupt firm union deep in the wound. Despite rigid aseptic operative technic, in excising pilonidal disease, cultures taken from the depths of the wound just before closure uniformly showed growth of septic organisms. In a small series of such cases we grew hemolytic staphylococcus albus in ten, anerobic streptococcus in six, hemolytic staphylococcus aureus in two, and streptococcus fecalis in one. The mechanism of recurrences following primary closure in most cases proceeds as follows: loss of fixation in the weak suture line between vascular subcutaneous areolar and avascular ligament in time results in a dead space, which becomes increasingly infected in the presence of low grade septic organisms to manifest itself eventually as a deep sinus tract. That sepsis, though universal in these cases, is of low virulence is shown by the fact that the well vascularized skin and subcutaneous areolar tissues in these wounds heal firmly.

Recurrences following excision of pilonidal disease in which the wound was left open to heal by granulation were less commonly seen in our cases. In these, recurrences probably was due to insufficient wound drainage and to lack of careful postoperative wound toilet, thereby allowing bridging of granulations and subsequent formation of infected sinuses.

## TREATMENT

A continuous series of 125 primary cases of pilonidal disease in which the patients were operated upon by a number of surgeons on our staff were reviewed. (Table III, Group I.) The prolonged time required for complete healing, complications and early recurrences in many of these clearly indicated that utilization of haphazard methods and technics generally prolonged hospitalization for many of these patients. Standardization of treatment was instituted in the last eight-month period during which a comparative series of patients were studied. (Table III, Group II.) Operation in this group of 116 patients was performed by one of three surgeons and postoperative care was supervised by one of us.

It is generally accepted that primary closure of wounds following excision of chronically infected pilonidal cysts and sinuses, when successful, heals in the shortest time and affords the most satisfactory scar. Therefore, many cases in Group I ill suited for primary closure were nevertheless so treated on the assumption that if the wound became infected and broke down, sutures could be removed and the resultant gaping wound allowed to heal by granulation. Our experience, however, showed that the grossly infected wound healed slowly as does all infected granu-

lation tissue, so that in most of these cases eventual epithelialization was markedly prolonged. In fifty-seven cases closed per primum in Group I varied technics and a variety of suture material were used. Although a wound closed by primary suture should be well and firmly healed in fourteen days, complete epithelialization in three weeks was arbitrarily established as the criterion of successful primary closure, because some technics required delayed skin closure.

TABLE III

TYPE OF DEFINITIVE SURGICAL TREATMENT IN PRIMARY PILONIDAL DISEASE—LENGTH OF TIME REQUIRED FOR COMPLETE EPITHELIALIZATION OF WOUND

| Cysts and sinuses chronic | Early Series—Group I 26 Surgeons Time in Weeks | | | | Type Therapy | Late Series—Group II 3 Surgeons Time in Weeks | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. Cases | Shortest | Longest | Average | | Average | Longest | Shortest | No. Cases |
| | 57 | 2 | 21 | 6 | Primary closure | 2.9 | 10 | 2 | 61 |
| | 29 | 4 | 20 | 7.5 | Partial closure | 5.5 | 7 | 5 | 12 |
| | 6 | 6 | 10 | 7.5 | Open drainage | 7.5 | 16 | 8 | 7 |
| Acute abscess | 33 | 4 | 28 | 9 | Varied-Group I Marsupialized Group II | 6 | 12 | 4 | 36 |

TABLE IV

EVALUATION OF METHODS OF PRIMARY CLOSURE OF PILONIDAL WOUNDS

| Methods | No. of Cases | Successful Less Than 3 Weeks | | Failure More Than 3 Weeks | | Healed Average Time in Weeks |
|---|---|---|---|---|---|---|
| | | No. | % | No. | % | |
| Primary partial (skin drained) cotton-dermal tension | 18 | 12 | 67 | 6 | 33 | 5.5 |
| Cotton-dermal tension | 13 | 4 | 30 | 9 | 70 | 9.0 |
| Catgut-dermal tension | 16 | 8 | 50 | 8 | 50 | 7.0 |
| Catgut-wire tension | 21 | 15 | 71 | 6 | 29 | 3.8 |
| Wire-wire tension (Ferguson) | 50 | 45 | 90 | 5 | 10 | 2.5 |

Table IV demonstrates the average healing time required by the several methods of primary closure in this series based broadly on the type of suture material used. One method, emphasized the importance of a specialized regimen of pre- and postoperative care to minimize infection. However, in a number of patients so treated preoperative preparation with wet dressings and bed rest required one to three weeks thereby nullifying the advantage of primary closure insofar as the time saving factor was concerned. Review of those cases in Group I classified as failures, (healing prolonged over three weeks), showed that breakdown of the wound usually was due to neglect of the fundamental physiological principles essential for proper wound healing. These included: (1) attempted closure of grossly infected areolar subcutaneous tissues too soon after incision and drainage of an acute suppurative pilonidal abscess; (2) attempted closure of defects so wide that suture lines cut through or gave way to excessive tension resulting in dead space and eventual infection thereof. A postoperative hematoma occasionally was seen.

In our personal cases, Group II, interrupted sutures of fine chromic catgut were used in our early cases to close the wound. Through-and-through tension sutures of wire strengthened the suture line. (Fig. 6.)

An excessive number of these early wounds became infected despite the fact that the wounds were particularly favorable for primary closure. We attributed the breakdown in the wound to excess tissue reaction to the chromic gut. Tissue irritants combined with septic organisms always present in these wounds apparently overwhelmed the process of normal healing eventually resulting in gross infection. In the later cases of Group II, catgut was discarded as suture material.

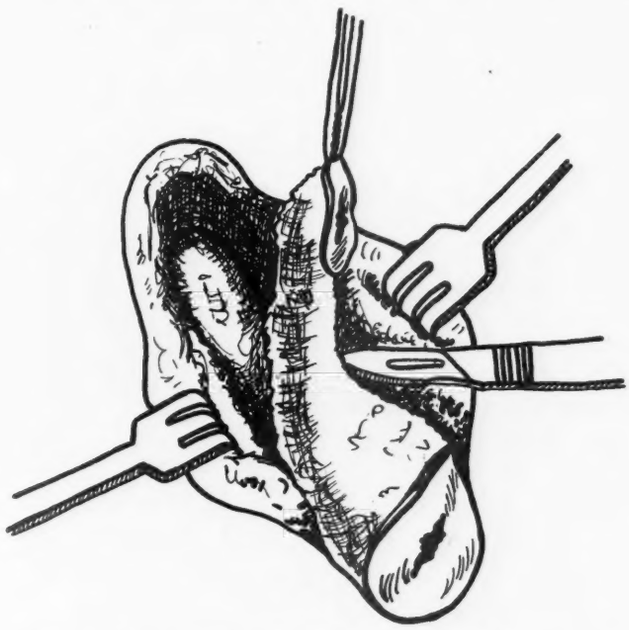

Fig. 4. Excision of sinus tract under local anesthesia.

### PRIMARY CLOSURE

In the entire series the method of primary closure which afforded consistently good healing in the shortest period of time was that in which alloy steel wire was used throughout with a technic slightly modified from that described by one of us, (F.), in 1935.[8] In fifty patients so treated, forty-five (90 per cent) were completely epithelialized in two weeks, the average healing time for all patients was two and one-half weeks from operation to complete epithelialization. (Table IV.) Our present technic of primary closure follows:

Preoperative medication consists of phenobarbital 0.2 (gr. III) two hours before operation. Patient is placed in the inverted prone position with adhesive straps separating the buttocks. After meticulously preparing the field, procaine solution 1 per cent containing 8 m. of $\frac{1}{1000}$ solution of epinephrine per ounce is infiltrated into the skin and subcutaneous tissues about the sinus tract and cyst, the extent of which can readily be determined in its superficial aspects by careful finger palpation. A local field block as well as a relatively avascular operative field results. The skin adjacent to and below the distal sinus opening is incised and dissected free. A towel clip through the distal sinus tract held in the operator's left hand and small sharp retractors on the skin margins held by the assistant serves to place the tissues under tension so that dissection of the lesion is markedly facilitated. (Fig. 4.) Chronicity of the lesion produces marked fibrosis around the cysts and sinuses so that with careful scalpel dissection the lesion can be shelled out removing only a minimum of surrounding normal skin and areolar tissue. It is essential to keep the level of the dissection as superficial as possible so as to preserve the all important post-sacral fascia. However, complete re-

moval of the infected sinus tract is essential. Lateral extensions are dissected out when found, additional procaine solution being infiltrated when necessary. Bleeding is usually minimal, due to the use of epinephrine, and controlled by hemostats when encountered. A cross-section of a favorable case for primary closure after completion of the dissection of the lesion is illustrated in Figure 2.

The wound is considered favorable for primary closure if the lateral walls can be approximated without undue tension and only if the post-sacral fascia remains intact. Hemostats are now removed, residual bleeders if any are caught and tied with fine plain catgut and the wound thoroughly irrigated with saline. Adhesive retracting straps are removed and the adjacent skin is again prepared and re-draped. Microcrystalline sulfathiazole is frosted into the wound by means of a powder blower. Using a cervix needle, a series of very fine alloy steel wire, .004 inch, sutures are placed at short intervals starting at the distal end of the wound. The suture incorporates the deep areolar tissue on both sides as well as a wide portion of the post-sacral fascia. (Fig. 5.) It is technically easier to place all the sutures before tying. Extremely fine wire is used for two reasons: (1) This very fine gauge wire gives rise to practically no tissue reaction; (2) its low tensile strength insures against excess tension in the wound. If the suture will not hold the approximated wound when tied, tension is considered excessive and primary closure in such a wound is therefore precluded. In deep defects, a second superficial layer of

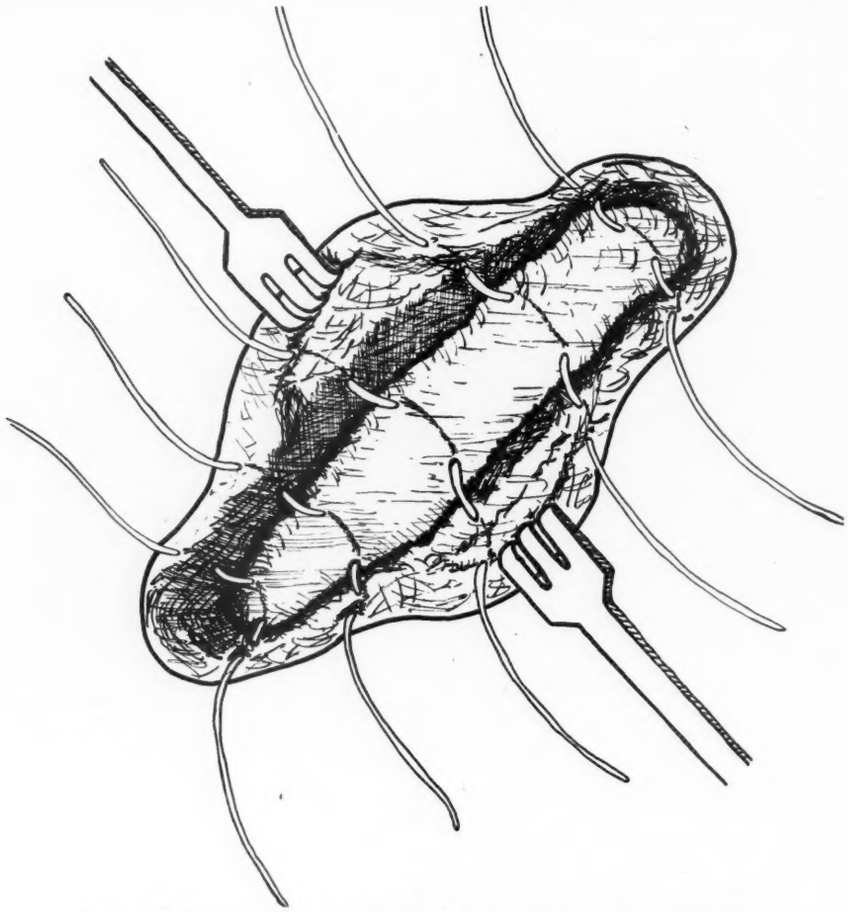

FIG. 5. Primary closure of pilonidal wound by use of approximating sutures of .004 alloy steel wire through deep areolar tissues incorporating the postsacral fascia.

.004 inch approximating sutures is used. All knots must be square, tied three times and cut on the knot to avoid sharp ends.

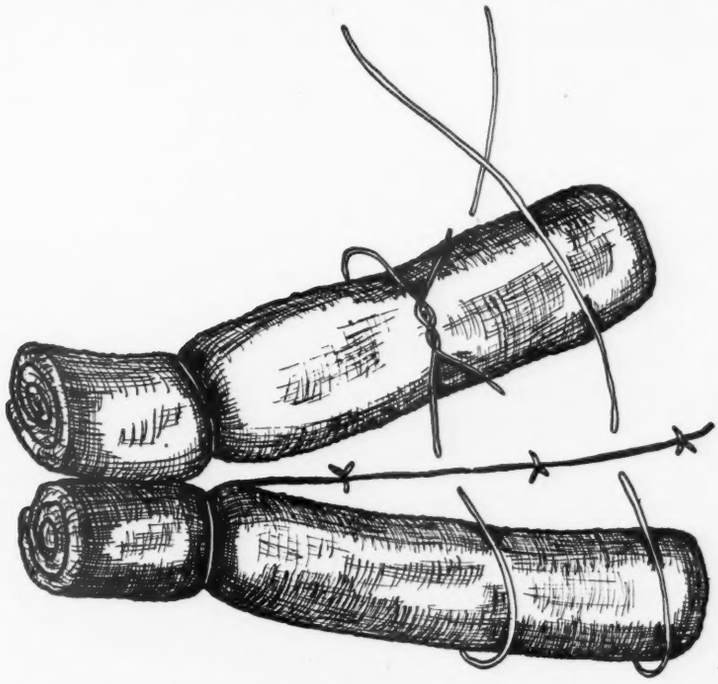

Fig. 6. Wound closure with .006 alloy steel wire vertical mattress sutures tied over gauze rolls. (Figs. 4, 5 and 6 after Ferguson, L. K. "Surgery of the Ambulatory Patient." Philadelphia, 1942. Lippincott.)

Microcrystalline sulfathiazole is liberally sprayed into the wound at frequent intervals as prophylaxis against gross infection.

Finally, through-and-through vertical mattress sutures of .006 wire are passed on large, curved cutting needles starting 3 cm. from the near skin edge. The near end is then threaded on a fine cutting needle and the skin edges are approximated. A few extra skin sutures may be required. The tension sutures are tied firmly over gauze rolls. (Fig. 6.) A dry dressing firmly held by wide adhesive straps placed across the buttocks completes the procedure.

The dressing is not disturbed for ten days but the patient may be ambulatory after the second day. Tension sutures are then removed, an alcohol dressing is applied and held with firm adhesive straps. Dressings are discontinued after the fourteenth postoperative day. To avoid pressure and tension on the fresh wound, the patient is cautioned to sit only on the lateral portion of the thigh and buttock with the opposite leg crossed over the knee during convalescence and for some time thereafter.

In those cases in which one or more lateral sinus tract extensions were present, the lateral wounds were sutured first, then closure of the main wound was completed as described. Wound infection is suspected if pain, tenderness, induration and possibly rise in temperature occurs on about the fifth postoperative day. If on inspection of the wound induration is found to be localized, penicillin, 100,000 to 200,000 units, often will prevent complete breakdown of the wound and induration will rapidly subside. Continued inflammatory reaction going on to fluctuation requires removal of stay sutures and reopening the wound for drainage.

### PARTIAL CLOSURE

Widespread chronic pilonidal cysts connecting distally with a sinus tract draining over the lower coccyx were present in

twelve patients of Group II. (Table III.) Lateral extension of the cyst necessitated extensive dissection which left a wide

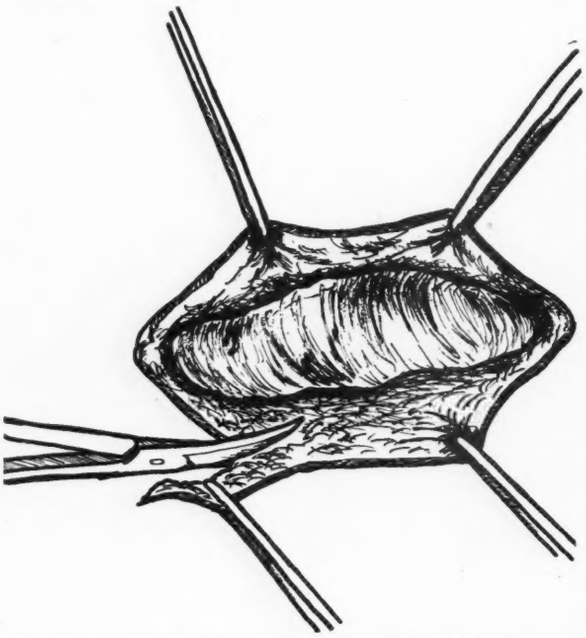

FIG. 7. Marsupialization of acute pilonidal abscess; saucerization of the wound. (After Buie.)

"banjo-shaped" defect. The width of the wound in its proximal portion precluded primary closure. However, in its distal portion primary closure was feasible and readily accomplished. The wide upper portion was then partially closed. The skin adjacent to the wound was mobilized by undercutting; wedges of subcutaneous fatty areolar tissue then were excised bilaterally to allow the skin to be drawn partially together thereby minimizing the width of the wound. The skin margins finally were secured to the underlying post-sacral fascia by several mattress sutures of alloy steel wire so that only a narrow central area remained to heal by granulation. These patients required four to six weeks for complete epithelialization.

### ACUTE ABSCESS

Acute suppurative pilonidal abscesses occurred in 22 per cent of patients in this series. Military expediency required definitive treatment in one uninterrupted period of hospitalization as stated above. We found that the method of management to be described resulted in the shortest period of hospitalization and afforded satisfactory end results.

Fluctuant abscesses were incised and drained in the ward dressing room on admission. Morphine sulfate gr. $\frac{1}{6}$ administered intravenously just before incision provided ample anesthesia. Application of wet dressings were continued for two or three days until induration about the wound receded. Secondary operation was then carried out under sodium pentothal anesthesia. After exploration of the wound with probe and gloved finger, the wound was saucerized by liberally excising skin and subcutaneous tissues around the wound cavity. A marsupialized wound results similar to that described by Buie. (Fig. 7.) By means of a large spoon curette infected granulation tissue in the base of the wound was removed. After adequate hemostasis iodoform gauze was packed firmly in the wound. The pack was removed on the fifth postoperative day and the wound was allowed to heal by granulation. Daily wound toilet, frequent hot irrigations, control of exuberant granulation tissue by silver nitrate stick helped to promote rapid healing. Epithelialization was usually complete in four to six weeks as evidence by a firm, flat mobile scar. (Table III.)

### RECURRENT PILONIDAL DISEASE

As stated two-thirds of our recurrent cases followed previously unsuccessful primary closures. Secondary operation was performed under sodium pentothal anesthesia. The sinus tract was exposed by cutting down on a grooved director lying in the sinus tract. This required incision through the overlying scar. Chronic granulations were removed with a spoon curette and wound edges were well saucerized. Iodoform packing completed the procedure. Recurrences after previous open type of operation were similarly treated by curettage and saucerization. Despite meticulous daily postoperative care and the use of all procedures in our therapeutic

armamentarium most of these wounds were very slow in healing. When the granulating wound had reached the skin surface it was found that epithelium would not grow across the small residual gap. The importance of adequate drainage in these wounds was demonstrated repeatedly in the more extensive wounds which extended from the tip of the coccyx to well up on the sacrum. The portion of the wound over the sacrum healed well and epithelialized rapidly. However, the lower portion in which drainage was obstructed by apposition of the buttocks, especially with the patient standing, healed sluggishly and final epithelialization was markedly protracted. In one patient who had had three previous operations for his recurrent lesion the distance from the depth of the pilonidal wound in the coccygeal region to the surface of the buttocks measured 8 cm. when the patient assumed the erect position. In this type of patient with a deep natal fold and large buttocks, adequate drainage was physically impossible. Chronicity of the lesion in the recurrent cases causes deposition of excessive fibrous tissue in the granular bed of the wound with resultant progressive inadequacy of the local tissue vascularity. This is another factor which retards healing.

Experience has shown us the difficulties in the surgical cure of patients with multiple recurrences. In several such recent cases, the local lesion was again excised thereby affording us a fresh clean wound. On this fresh wound, a split thickness skin graft taken from the lumbar back was fitted and sutured, then held firmly in place with a pressure dressing. The few cases in which the patients were so treated by the plastic surgical service have been eminently successful and this procedure appears to offer a solution to this very troublesome problem. Rank[9] has recently described a similar procedure.

## SUMMARY

1. Pilonidal inflammatory disease is common in the Navy. At our Naval Hospital, 7.5 per cent of operations in a recent period were performed for the eradication of this condition. The definitive surgical treatment of a series of 319 patients was reviewed. Of these 241 (75 per cent) were primary admissions and seventy-eight (25 per cent) had previously had one or more unsuccessful definitive surgical operations.

2. Pilonidal cysts and sinuses can originate in embryo from the neurogenic medullary canal, from infolding of the dorsal epidermis or from both. Three clinical types result: subcutaneous cyst alone, (neurogenic); sinuses or dimple alone, (epidermal); subcutaneous cyst communicating with sinuses (neurogenic and epidermal).

3. We find no convincing evidence to prove that hair grows from the epithelium of pilonidal cysts. We believe that external hair grows into the sinus, extends into the cyst, breaks off from the external root and in time is moulded into "nests."

4. Pilonidal inflammatory disease in our clinical cases occurred in four main types: (1) sinuses, (2) acute abscesses, (3) infected subcutaneous cyst and sinuses, and (4) infected subcutaneous cyst alone. Treatment of these types varies for each type as well as for individual variations in type.

5. Recurrent pilonidal disease following previous definitive operation is common; seventy-eight cases in this series. In two-thirds of these, recurrence resulted from unsuccessful primary suture. With characteristic uniformity the lesion in most of these consisted of a deep sinus under a well healed scar. That fundamental surgical principles were disregarded by the original surgeon is indicated by the uniformity of the recurrent lesion. Relationship of surgical repair to the basic anatomy of the sacrococcygeal area is emphasized as a requirement for success in primary closure of these wounds.

6. It was demonstrated that haphazard technics of operation and postoperative management resulted in prolonged hospitalization of many of our patients.

In the second half of the series, operation and management of these cases was standardized under the care of three surgeons with resultant reduction in healing time in each type of case.

7. Patients amenable to primary closure were operated upon under procaine-epinephrine local anesthesia. The infected cyst and sinus was carefully excised and the wound was closed with fine alloy steel approximating sutures reinforced by through-and-through tension sutures of heavier wire tied over gauze rolls. Only five of fifty patients so treated required more than three weeks for complete epithelialization. The average healing time for all fifty patients was two and one-half weeks.

8. Cases necessitating wide excisions were partially closed by undermining the skin at the wound margins and suturing these to the post-sacral fascia, thereby minimizing the wound which is then allowed to heal by granulation.

9. Acute abscesses were drained on admission. Revision operation three days later consisted of marsupialization of the wound by saucerizing the margins thereof. Granulations in the base of the wound were curetted and healing allowed to proceed by granulation.

10. Recurrent lesions were explored after exposure, granulations were curetted and wound edges saucerized. As a rule, these healed poorly for two reasons: (1) depth of the lesion especially in the upright position prevented adequate drainage; (2) chronicity of the lesion resulted in marked fibrosis in the wound bed with consequent embarrassment of adequate vascularity. In recent sluggish cases, the wound was excised providing a fresh clean wound. A split thickness skin graft was removed from the lumbar back and sutured onto the fresh wound. A pressure dressing maintained the graft. This procedure has afforded gratifying results in several recalcitrant cases.

11. In postoperative granulating wounds, meticulous and daily wound toilet is necessary to attain healthy granulations and early epithelialization.

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# STRICTURE OF THE MALE URETHRA

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IT is the purpose of this communication to present an analysis of eighty-seven cases of urethral strictures treated in an Army General Hospital overseas in a period of twenty-two months; 1077 cases of urethritis were treated during the same period. A description of the symptoms, signs, diagnosis, treatment and disposition of urethral strictures will be given.

Stricture of the urethra is the most insidious and at the same time the most common late complication of gonorrhea. Trauma is a more serious but less common cause of stricture. Inflammatory stricture is usually acquired in early life but often does not become manifest for years. When this is the case, there is an accompanying infection of the mid and upper urinary tract which is proportionate to the severity of the urethral obstruction. Early recognition of the presence of a stricture permits the institution of appropriate measures to prevent constriction and obstruction of the urethra. The treatment, though primarily palliative and not curative, may obviate subsequent pathologic changes in the mid and upper urinary tract.

All of the patients were in the third and fourth decades of life, except three in the fifth and three in the sixth decade. There were seventy-six patients who previously had gonorrhea, four had sustained severe trauma to the urethra, one had a congenital structure, and six denied any history to explain the presence of the lesion. Fifty-nine of the patients who had had gonorrhea had been treated with sulfonamides for their infection and seventeen had not had any of these agents. None had received penicillin and only three had been treated with fever therapy. There were forty-nine white and thirty-eight negro soldiers in the group.

The presenting symptoms of our patients are shown in Table 1.

TABLE 1

| | |
|---|---|
| Chronic urethral discharge | 32 |
| Chronic urethral discharge and obstructive symptoms | 23 |
| Obstructive symptoms alone | 12 |
| Acute urethral discharge due to gonococcus | 14 |
| No symptoms due to stricture | 6 |

Thirty-two patients complained of urethral discharge of long duration and usually manifested as a "morning drop." This discharge varied from a thin watery fluid containing epithelial cells and a few leucocytes to a mucopurulent fluid loaded with leucocytes. Twenty-three patients had a chronic urethral discharge and also complained of a weak, small, hesitant urinary stream. Twelve patients had the latter symptoms without noticeable urethral discharge. Acute gonorrheal urethritis was present in fourteen patients who also had stricture of the urethra. This was the second attack of gonorrhea for these patients. There were six patients who had no symptoms and in whom the diagnosis of stricture was made when cystoscopy was attempted for other reasons. The lapse of time between the original gonorrhea and the diagnosis of stricture varied from one to twenty-seven years, with the majority evenly divided between one and twelve years. Only ten patients were aware that they possessed a stricture before their current hospitalization. One patient with a known stricture of twenty years' duration entered the hospital with acute urinary retention. His temperature was 103°F. and he pre-

sented the signs and symptoms of severe urinary tract infection. This was the only patient of our series who was admitted in a critical condition. There was one patient admitted here six weeks after a bulldozer turned over on him and fractured his pelvis and ruptured his urethra. A suprapubic cystotomy had been performed at the time of injury, but no attempt had been made to restore the continuity of the urethra.

The following outline is adhered to in the investigation of patients with stricture of the urethra:

1. *History.* Careful attention is given to the duration of symptoms, especially to any history of antecedent upper urinary tract infection. It is also of paramount importance to discover how incapacitating the disease has been in relation to the type of military duty the patient has been performing. If the urethral discharge is present it is important to inquire into recent sexual exposures.

2. *Physical Examination.* A complete physical examination is made which includes palpation of the urethra, testicles, epididymes, prostate and seminal vesicles.

3. *Observation of the Patient during the Act of Urination.* The importance of this simple test is often overlooked, and deserves particular emphasis. Not only does it demonstrate the force and calibre of the urinary stream but it is an aid in following the subsequent course of the patient under treatment.

4. *Urinalysis.* Frequent examination of the urine is essential.

5. *Renal Function.* Evaluation of renal function is made by using the phenolsulphonephthalein excretion test, the concentration test, and the non-protein nitrogen content of the blood.

6. *Calibration of the Urethra.* This is accomplished by passing curved steel sounds, woven or steel bougie a boules or woven bougies. If acute urethritis or prostatitis is present, calibration is postponed until the infection has subsided. In many instances there is chronic urethritis which is kept active by a stricture. In such cases gentle calibration is performed to determine if a stricture is the underlying factor.

7. *Volume of Residual Urine.* Where possible a small soft rubber catheter is passed after the patient has voided to establish the amount of retained urine. If the stricture is impermeable, palpation of the bladder reveals the degree of distention.

8. *Smears and Cultures.* Smears are made of any urethral discharge and of the prostatic and vesicular secretion. Cultures are likewise made upon both chocolate agar and blood agar.

9. *Cysto-urethroscopy.* The use of an instrument with fore-oblique vision gives direct visualization of the stricture; the entire urethra and bladder can be examined if the lumen of the stricture permits the instrument to pass. It is most useful in visualizing the stricture and any exudate or ulceration of the urethra.

10. Cysto-urethrography. The urethrogram provides accurate information concerning the calibre and contour of the stricture.[1] A cystogram is usually made at the same time by first filling the bladder with the opaque solution which is instilled through the urethra without using a catheter. Ten per cent skiodan or sodium iodide solution gives satisfactory contrast, and films are made in both anteroposterior and oblique positions. An accurate idea of vesical function can be obtained by making a roentgenographic exposure during the act of micturition in the lateral oblique position.

11. *Pyelography.* Excretory urograms are made when there is no significant diminution of renal function.

Therapy of urethral stricture may be divided into a consideration of treatment of the stricture itself and that of the accompanying infection of the upper, mid and lower urinary tract. In civil life urethral strictures are treated as a rule in the office or out-patient department except in the most severe cases, and the patient

can carry out his daily business while his stricture is dilated at intervals over a long period of time. In the Army, however, a patient is usually treated in the hospital until ready for military duty. In addition, when the individual patient with stricture is evaluated it must be decided whether he will be able to perform full or limited military duty overseas, or whether he should be evacuated to the United States.

If the stricture is readily amenable to instrumental dilatation, as manifested by easy passage of curved sounds to a calibre of 24 or 26 French scale without bleeding, no further hospitalization is required. The patient is returned to duty with instructions to have his unit medical officer continue with calibration every one or two months. This type of patient required two to three weeks' hospitalization as the dilatations are done at six to seven-day intervals. In the technic of urethral instrumentation we instill a semi-fluid mixture of ½ per cent nupercaine solution or 4 per cent boric acid solution and a sterile water-soluble surgical lubricant before passing urethral instruments. This acts as an excellent hydrostatic dilator and insures complete lubrication. Fifty-six of our patients were treated in the above manner. Fifty-four of these strictures were 12 to 14 cm. from the meatus and two were 5 to 8 cm. from the meatus. The strictures that can be treated in this manner are the most favorable type and have a minimum of urinary infection. Sulfathiazole is administered for three days prior to dilatation and for several days thereafter.

Internal urethrotomy is a valuable procedure to increase quickly the calibre of a stricture in selected cases. Our criteria for the use of this operation are as follows: (1) The stricture is not impermeable. (2) The stricture is located in the anterior urethra, i.e., within the penile or bulbous urethra. (3) The stricture is not amenable to dilatation due to: (a) tortuous lumen, (b) associated bleeding from the adjacent urethra distal to the stricture, and (c) inelasticity of the stricture due to dense scar tissue. (4) The stricture is of small calibre, i.e., less than 18 French scale.

The operation is done under spinal or caudal anesthesia, and the Maisonneuve type of urethrotome is used. After the stricture is cut, further dilatation is carried out by the passage of curved steel sounds. A soft rubber catheter, 20 or 22 French, is then left in the urethra for not more than three days. While the catheter is in place, sulfathiazole 1.0 Gm. four times a day is given. On the seventh or eighth postoperative day, dilatation of the urethra is started and is continued at weekly intervals until the calibre remains constant and the wound in the urethra has healed. About one month of postoperative hospitalization is necessary for these patients. When they return to duty they are instructed to have urethral calibrations at intervals of one to two months. There is very little bleeding at the time of the internal urethrotomy, which is in accord with the fact that most urethral bleeding following instrumentation for stricture comes from the adjacent mucosa. The stricture is relatively avascular. Patients who have undergone internal urethrotomy have amazingly little discomfort and all notice a marked improvement in their urinary stream when the catheter is removed. Internal urethrotomy was the treatment of choice for twenty-six of our eighty-seven patients. Three of these strictures were 5 to 8 cm. from the meatus, and twenty-three were 12 to 14 cm. from the meatus. The type of stricture that meets the criteria for internal urethrotomy is severe and on instrumentation alone a prolonged period of hospitalization is required. The value of internal urethrotomy lies in the fact that simple incision of dense scar tissue is less traumatic to the urethra than dilatation accomplished by repeated passage of steel sounds.

External urethrotomy was the procedure of choice in four patients. The indication for the operation was the presence of an impermeable stricture caus-

ing urinary retention. Three of these patients had post-inflammatory strictures of long duration, associated upper urinary tract infection and diminished renal function. One of them entered critically ill with acute urinary retention and a prostatic abscess. The drainage of the infection and the relief of the bladder obstruction were accomplished by perineal section. Calibration of the urethra was started eight to ten days after the operation. However, because of the severity of the stricture and the effect of longstanding stasis, these patients could not be sent to duty. The fourth external urethrotomy was performed upon a soldier who six weeks previously had suffered a ruptured membranous urethra and a fractured pelvis. A suprapubic cystotomy had been performed at the time of injury, and at the time of admission to this hospital he had an impermeable stricture and was on suprapubic drainage. An external urethrotomy was performed and a seton was passed through the urethra to the bladder at the time of operation; dilatation was then carried out using the seton as a guide. It is not in the province of this article to discuss the management of rupture of the urethra, several aspects of which have been stressed elsewhere by one of the authors.[2] The best results in the treatment of rupture of the bulbous urethra have been obtained by immediate external urethrotomy, whereas the operative management of rupture of the membranous or prostatic urethra consists of combined suprapubic and perineal approach. Furthermore, the stricture resulting from trauma calls for a long period of observation and calibration as the scar tends to be more dense than that following inflammation alone.

As a corollary to treatment of stricture of the urethra, it is important to stress that no urethral instrumentation should be performed if there is a co-existing acute infection of the urethra, prostate, seminal vesicles or epididymes. In addition, gentle instrumentation is essential as much harm will be done if the operator is rough. It also must be stressed that a stricture is composed of scar tissue which will always be present, so that any operative procedure must not be regarded as a cure, but as a means to permit dilatation of the stricture in order to obtain a urethral calibre that is compatible with normal urinary function.

The complications of instrumentation of urethral strictures are transient bacteremia or so-called "urethral fever," peri-urethral abscess, urethral fistula, extravasation of urine, and acute epididymitis, prostatitis and pyelonephritis. The only complications that we encountered were in two patients who developed acute pyelonephritis, one after internal and one after external urethrotomy.

The criteria for the return of the soldier with urethral stricture to full military duty are as follows: (1) The patient is asymptomatic. (2) The urinary stream is free and of good calibre. (3) There is no upper urinary tract infection or impaired renal function. (4) There is no active urethritis, prostato-vesiculitis or epididymitis. (5) The urine sediment is free of cells and casts. (6) The calibre of the stricture is at least a 22 French and of such nature that a curved sound can be easily passed.

If the patient does not meet the above requirements, he cannot be properly cared for in the field. Seventy-one of our patients were returned to full duty. Six patients were returned to the United States because of the stricture and associated upper urinary tract infection. Ten patients were returned to the United States because of other diseases and not because of their urethral strictures. The four patients who underwent external urethrotomy and one patient who underwent internal urethrotomy were among those returned home because of stricture. One patient who also had benign hypertrophy of the prostate was not treated but evacuated home, because it was not thought justified to start treatment overseas because of the long hospitalization and eventual disposition.

SUMMARY

1. Eighty-seven cases of urethral stricture in which the patients were treated at a General Hospital overseas are reviewed.

2. The majority (seventy-six) of the strictures were a sequel to gonorrhea; four were post-traumatic, one was congenital, and in six the history was noncontributory as to cause.

3. Chronic urethral discharge and difficulty in urination were the main presenting symptoms. However, fourteen had acute gonorrhea.

4. The urologic investigation of urethral stricture is outlined with emphasis on the value of (1) observation of the patient with stricture during the act of micturition, (2) cysto-urethroscopy and (3) urethrography.

5. The treatment and indications for the type of treatment are outlined.

6. Fifty-six patients were treated by urethral dilatation; twenty-six patients had internal urethrotomy, and four had external urethrotomy. One patient received no instrumental treatment.

7. Seventy-one patients were returned to full military duty; six were returned to the United States because of urethral stricture and its complications, and ten were evacuated home because of reasons other than urethral stricture.

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# INTUSSUSCEPTION*

## DIAGNOSIS AND TREATMENT

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AT the Rhode Island Hospital, Providence, Rhode Island, during the ten-year period from 1934 to 1944, thirty-five patients with intussusception have been treated, ranging in age from five weeks to sixty years. Of this group, thirty-one were operated upon, with five deaths, or a mortality of 16.1 per cent. Of the other four, two died shortly after admission to the hospital, and the other two had spontaneous cures, probably resulting from the physical examinations to which these patients are usually subjected. This can readily be appreciated when one considers that the average time elapsed between admission for this condition in this hospital has maintained an average of one every three and one-half months.

That intussusception is a disease of extreme youth has been ably demonstrated by Ladd and Gross in 1934 in their report of 372 cases and again by Kahle in 1941 in his report of 151 cases.

The name is derived from two Latin words: "intus" meaning "within," and "suscipere" meaning "to receive." Or more specifically "a receiving within" and interpreted in surgical circles as the invagination or indigitation of a portion of the intestine into an adjacent portion. It was first described by John Hunter in 1789.

There are four varieties: (1) Ileocecal, in which the ileum and the ileocecal valve pass into the cecum and colon; (2) colic, in which the large intestine is prolapsed into itself; (3) ileal or jejunal, as the case may be, in which the small bowel is invaginated into itself, and (4) ileocolic, in which the ileum passes into the ileocecal valve.

The invagination of a lower portion of the bowel into a higher part may also occur. As there was no incidence of this latter type of disorder, only those cases in which the intussusception has occurred from above downward within the gastrointestinal tract will be considered in this report.

Of these thirty-five cases the sex incidence varies little from the predominantly male percentage presented by other writers. There were twenty-four males or 68 per cent and eleven females or 32 per cent.

Of the female group there were three patients who were over seventeen years of age, or approximately 25 per cent. In the male age group, there were seven cases occurring in patients eight years old or over. All of the others occurred in infants and twenty-one of these infants were under one year of age. The other three were between one and two years.

In further breaking down the age percentages, twelve cases occurred in infants under six months of age, or 33 per cent. An additional 22 per cent occurred in the age group between six months and one year, or a total of 57 per cent. Of the entire group, there were three cases occurring between birth and three months of age. In Table 1 a composite picture of sex and age and the percentage in each is given.

The etiological factor in the entire series is as obscure as it has always been. There were seventeen cases in which the cause could be found at operation. The remaining fourteen patients operated upon had no apparent etiology. In view of these

* The opinions expressed herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

| Age | Male | Female | Male, Per Cent | Female, Per Cent | Total, Per Cent |
|---|---|---|---|---|---|
| Under 3 mos..... | 3 | 0 | 8.57 | 0 | 8.57 |
| 3–6 mos..... | 4 | 5 | 11.58 | 14.15 | 25.73 |
| 6 mos.–1 yr..... | 7 | 1 | 18.86 | 4 | 22.86 |
| 1–2 yr..... | 2 | 0 | 5.72 | 0 | 5.72 |
| 2–10 yr..... | 4 | 1 | 11.26 | 3 | 14.26 |
| 10–20 yr..... | 2 | 2 | 5.71 | 5.71 | 11.43 |
| Over 20 yr..... | 3 | 1 | 8.58 | 2.85 | 11.43 |

findings, the treatment of the disease must still be delegated to the correction of the acute symptoms at the earliest possible moment. In the age group up to one year, there were twenty patients of whom three were treated without operation. Eleven of the remaining seventeen cases demonstrated no definite etiological factor at the time of operation. The six patients in which a cause could be seen have a representative in each of the etiological groups as shown in Table II. It is, therefore, sufficient to say that a definite pathological background in the infant group is no better known than ever. In the older ages, particularly adults, a cause was always found. This included in this series all eight operated patients over ten years of age.

| Cause | Total | Under 1 Year | 1–10 Years | Over 10 Years |
|---|---|---|---|---|
| None found..... | 14 | 11 | .. | 3 |
| Tumor in intestine..... | 6 | 1 | 1 | 4 |
| Meckel's diverticulum... | 4 | 2 | 1 | 1 |
| Adhesive band..... | 4 | 2 | 1 | 1 |
| Hyperplasia of lymphoid tissues..... | 3 | 1 | .. | 2 |
| Not operated..... | 4 | 1 | .. | 3 |

Of the four varieties of intussusception usually encountered, as already defined above, the most common is found in the region of the cecum, either ileocolic or ileocecal, and in this series amounted to 50.7 per cent of the group. The ileocolic type was found in ten cases (28.5 per cent). The ileocecal valve was incorporated in the intussuscepted mass in eight cases (22.2 per cent). This particular anatomical area was further increased by the five cases presenting multiple intussusception, all of which showed the ileocecal region as one of the points involved. These twenty-two cases presenting pathological conditions in the region of the ileocecal valve were all infants under thirteen months of age, with the exception of four adults. The five cases presenting multiple intussusception included three infants under seven months of age, with an ileo-ileal and ileocolic intussusception of unknown etiology, and one adult female thirty years of age with an ileo-colic and ileo-ileal intussusception resulting from a fibroma of the ileum. The other patient presented a colocolic and ileocolic intussusception in an infant nine months old. Thus of the entire series, 62.8 per cent presented the condition in the lower right quadrant.

There were two patients in the group presenting large bowel disorders only. The first was a seventeen year old female, who presented a ceco-cecocolic intussusception arising from a soft tumor of the cecum. The other occurred in a boy of six who presented a colocolic intussusception at the splenic flexure with no apparent cause. The remaining six patients operated upon demonstrated the disorder in the small intestine alone, five in the ileum and one in the jejunum. Two of these patients fall into the group in which no cause could be found. The ten-year old boy with a jejuno-jejunal intussusception was found to be suffering from an adenocarcinoma of the jejunum. The oldest patient in the group, a man age sixty, with an ileo-ileal intussusception was found to have a fibroma of the ileum. The first patient was a re-operated patient who had complained of abdominal pain for three months prior to admission, and had had an appendectomy seven weeks previously. The apparent etiological factor producing the condition was omental adhesions arising following the appendectomy. The sixth case occurred

in a fifteen-year old boy, with a Meckel's diverticulum, in a section of which pancreatic tissue was found by the pathologist. This same patient had been ill for three days before admission, presented a gangrenous intestine which was resected. He subsequently died on his fourth day of peritonitis.

DISTRIBUTION—AGE AND TYPE, AGE

| Type | 1–3 Mos. | 3–6 Mos. | 6 Mos –1 Yr. | 1–2 Yrs. | 2–10 Yrs. | 10–20 Yrs. | Over 20 |
|---|---|---|---|---|---|---|---|
| Ileocecal | .. | 5 | 3 | .. | .. | 1 | |
| Ileocolic | *1 | 3 | 2 | 1 | 1 | .. | 2 |
| Colic | .. | .. | .. | .. | 1 | 1 | |
| Ileal or jejunal | .. | .. | .. | 1 | 1 | 3 | 1 |
| Multiple | .. | 1 | 3 | .. | .. | .. | 1 |
| Total | *1 | 9 | 8 | 2 | 3 | 5 | 4 |

* 5 weeks old male, not operated. Pathology demonstrated at autopsy.

EIGHT RESECTIONS, AGE

| Type | 6 Mos. | 8 Yrs. | 10 Yrs. | 13 Yrs. | 15 Yrs. | 17 Yrs. | 30 Yrs. | 60 Yrs. |
|---|---|---|---|---|---|---|---|---|
| Ileocecal | *1 | | | | | | | |
| Ileo-ileal | .. | 1 | .. | 1 | †1 | .. | .. | 1 |
| Jejunojejunal | .. | .. | 1 | | | | | |
| Ileo-ileal and ileocolic | .. | .. | .. | .. | .. | .. | 1 | |
| Ileocolic | .. | .. | .. | .. | .. | 1 | | |

* Died one-half hour after operation, of shock.
† Died on fourth postoperative day, of peritonitis.

Although this portion of the series represents only 20 per cent of the patients operated upon, it is interesting to observe that only one occurred in infancy without involvement of the ileocecal valve.

Subjective and objective symptomatology in the series shows no remarkable variation from the usual classical picture. Temperature changes in the entire series varied from subnormal to 103.6°F. The younger patients, as is the case in most types of disease, had a tendency to run a higher temperature. There were, however, ten of the patients who showed no temperature. The average for all of the patients was 99.8°F. or very similar to most groups of patients admitted for appendicitis. The common symptoms observed were those usually encountered in the evaluation of any acute condition of the abdomen, but the most constant were nausea and vomiting, occurring in twenty-two out of the thirty-five patients and abdominal pain in the same number. Diarrhea and distention occurred in four and five patients, respectively, and rectal bleeding was observed in eleven. A mass was palpable abdominally in twenty-one patients and rectally in eight. It is interesting to record that three of the eight patients in whom a mass could be palpated rectally, no abdominal mass could be observed. This again merely emphasizes how important can be the evaluation of the patient as a whole, with rectal examination a possibly serious omission if not done. It would also demonstrate quite conclusively that the typical textbook picture cannot always be reliable. The type and character of the mass palpated in the abdomen was not in any of the cases compared to the customary and too infrequent "olive, lime, sausage, lemon or grapefruit," but described as extending "throughout the right lower quadrant," "small or large," "below and to the right of the umbilicus," or as the case might have happened to be. This type of description is obviously much better than the more indefinite comparisons to common variables. Diagnosis was made preoperatively in twenty-four cases and confirmed at the time of operation. The remaining seven patients were operated upon because they had signs and symptoms of an acute surgical condition of the abdomen. Although the mortality was comparable to others recently reported in this serious surgical condition, not one of the seven patients who were not diagnosed previous to operation failed to recover. This again bears out the oft disputed rule that little harm can be done by simple laparotomy in cases in which there is reasonable doubt. In arriving at the point of decision as to the proper type of treatment, the general appraisal of the patient was probably given the greatest consideration. It can be an indisputable opinion that a patient requiring surgery of the abdomen can be

diagnosed from the history and physical examination in a large majority of cases. The dispute that arises always in the evaluation of these procedures is the exception for which a complete study in the laboratory and *x*-ray department are so vitally necessary. The use of the barium enema as a diagnostic procedure was limited to only three patients. Two of these were admitted shortly after the onset of symptoms and the third was over twenty-four hours old. In each patient the condition was correctly diagnosed, but not cured by the procedure, as has been reported by other observers. The white blood count was also extremely variable, and equally unreliable, ranging from 7,000 in a case which was a few hours old to 35,000 in one of the cases which terminated fatally.

Surgical therapy in each of the thirty-one patients operated upon consisted of reducing the intussusception from below upward in all cases except those that required resection. The practice of traction on the proximal loop of bowel is to be condemned as much as an obstetrician would condemn traction on the umbilical cord during the third stage of labor. If the mass cannot be reduced by gentle pressure over the distal point of intussusception, the possibility of the need for resection must be given more immediate consideration. Some writers have advised that this situation should be handled by suturing the bowel in place around the mass, leaving the mass to slough out. The advanced degree of shock may make this decision necessary, but a mortality is almost certain to follow this procedure. The risk of providing some means of diverting the intestinal stream is also great, but attended by a smaller mortality, as statistics have definitely shown. The incision in these cases was some type through the right rectus muscle, either splitting or retracting in twenty-seven of the thirty-one patients operated upon. Of the other four cases, three incisions were through the left rectus muscle and the fourth was through a right transverse incision. The relationship of mortality to the type of incision cannot be very satisfactorily demonstrated in such a small series of cases. Of the five deaths, three were in the group of patients in whom a right rectus incision was made, one left rectus, and the last the only transverse incision in the entire group. It is interesting to note that the patient in whom a transverse incision was made was five months old, had been ill for thirty-six hours previous to operation, was one of the three patients in whom a barium enema had sustained the diagnosis, had passed bloody stools, had a Meckel's diverticulum as the etiological factor, and died on the operating table. The type of incision many times may have a direct bearing on the end result, and although the incision that follows the natural skin creases has in my experience proved to be more physiological, it does consume more time in reconstructing, particularly if the rectus muscle has been divided in the line of the skin incision. It would, therefore, follow that intussusception in an infant should contraindicate any incision that is more time consuming, particularly if a general anesthetic has been used.

Resection of a loop of bowel was necessary in eight patients of the series, two of whom died on the fourth and eighth postoperative days, respectively. An ileotransverse colostomy was performed on one other patient in whom a tumor could be felt in the cecum. This patient was discharged on his fifteenth postoperative day and returned for the second stage six weeks from the time of the first operation. Recovery was prompt and uneventful following resection of the terminal loop of ileum, cecum and ascending colon. In these eight cases a side-to-side anastomosis was performed rather than end-to-end. This is unquestionably the better procedure, particularly if the experience of the operator is limited. The technical details of a side-to-side anastomosis consume a little more time, but the complications are much less troublesome.

Appendectomy constituted a part of the operative technic in thirteen of the operated group, whether the appendix appeared to be involved in the etiological process or not. Fortunately none of these patients were among the few deaths, but appendectomy as a routine procedure in the treatment of such a possibly serious condition is to be condemned, unless it can be shown to be definitely diseased.

Of the entire group of operated patients that recovered, the average hospitalization was fourteen days. The shortest hospitalization was a nine months old infant, discharged on the seventh postoperative day, following operation which revealed the ileocolic and a colocolic intussusception. The longest hospitalization was twenty-six days, and was necessary in two patients. The first was a mal-nourished eight months old infant in which no complication had occurred following the reduction of an ileocolic intussusception. The second was a thirty-two year old male who developed pneumonia on his fourth day following the reduction of an ileocecal intussusception.

Other complications following operation were limited to four patients, the remainder of the group surviving operation following an uneventful course. Abscess of the leg developed in a two and one-half year old female following hyperdermoclysis. Atelectasis, which was bronchoscoped in an eight-year old boy, was followed by an uneventful recovery and discharge on his thirteenth postoperative day. These two patients were the only complications encountered in the group of eight in whom some type of intestinal resection had been performed. Evisceration occurred on the sixth postoperative day in a seven months old infant, was resutured the same day and the patient discharged recovered fifteen days later. Intestinal obstruction occurred in a three-months old male infant a month after discharge, following operation for an ileocecal intussusception. At the reoperation numerous adhesions were found.

The actual mortality of 16.1 per cent in the patients operated upon is increased to an over-all mortality of 17.1 per cent for treatment of the entire series, because of the death of one patient admitted in a moribund state and not operated upon. A fifteen-year old male died on his fourth postoperative day of intestinal gangrene and peritonitis. At the time of operation a section of 15 cm. of gangrenous bowel was resected. The second death occurred in a one-year old male on his fourth postoperative day of lobar pneumonia. The third has already been mentioned, dying on the operating table. The fourth patient was a six-months old infant with an ileocolic intussusception in which the terminal ileum and part of the ascending colon were gangrenous at the time of operation. The fifth death occurred in a six months old female who had been sick for three days prior to operation and was one of the group in which resection was performed. This patient also died about one-half hour after operation.

Recurrent intussusception and its treatment did not enter into any portion of this report as there were no cases available in which a diagnosis had been definitely established. One patient admitted twice during the period of this report had a presumptive diagnosis of recurrent intussusception, but at each admission did not seem to offer sufficient diagnostic evidence for operation, and was discharged each time after a hospital stay of a few days. The low incidence of recurrence in this condition as shown in this series and reported by other writers should be a stimulus for a greater effort to determine the etiology by more complete and meticulous observation.

## SUMMARY

1. Thirty-five cases of intussusception occurring at the Rhode Island Hospital Providence, Rhode Island, from 1934 to 1944 have been recorded.

2. An operative mortality of 16.1 per cent is reported.

3. A cause was found at operation in 49 per cent of the series.

4. The sex incidence was 68 per cent males and 32 per cent females.

5. Resection was necessary in eight cases, with two deaths.

6. The value of a complete study prior to early operation in this acute surgical abdominal condition is again emphasized.

7. The possibility of determining the etiology of this disease in a greater percentage of patients in the future is forecast.

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PYLORIC occlusion with secondary vomiting and dilatation of the stomach occurs either from cicatricial contraction or from the swelling and edema associated with an ulcer. Rare complications are the occlusion of the bile duct with stone formation and jaundice; and pancreatitis from invasion of the pancreas or obstruction of a pancreatic duct.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

# VALUE OF SALPINGOGRAPHY IN SURGICAL DIAGNOSIS

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IN dealing with the so-called adnexal mass, the experienced surgeon and gynecologist are often unable to anticipate or plan the correct operative procedure because of their inability to identify its origin, type or definitive pathology. Difficulties in the differential diagnosis of this particular class of pelvic abnormality arise from several generally recognized sources.

Unfortunately, in a large proportion of adnexal tumors, a marked resemblance in the consistency, conformation, size and position, as well as in the intrinsic degrees of pain and tenderness is manifested by distinctly dissimilar tubal, ovarian or tubo-ovarian masses. Very seldom in these cases is an accurate differentiation of textbook clarity available from data obtained by careful laboratory study and history. Furthermore, the similarity between adnexal and uterine tumors not uncommonly met with in bimanual examination, may also be the basis of error in identification.

The adnexal growth presents no greater diagnostic problem than when it must be differentiated from the low abdominal tumor; and especially since an intestinal or renal tract neoplasm may be present which requires specific preoperative preparation of the patient and special surgical technics best performed by the urological or abdominal surgeon, the clinical importance of this distinction requires no further emphasis.

An obese abdominal wall, the patient's resistance, and the examiner's subjective error or personal factor are also sources of incorrect diagnosis, which although of academic interest, constitute a relatively frequent and important barrier, germane to all clinical problems of this type.

In view of these obstacles, it is not surprising that diagnosis of tubo-ovarian conditions has been the subject of numerous contributions to surgical literature. Descriptions of the operative findings include not only different and unexpected types of adnexal disorders, but also extrapelvic entities such as prolapsed kidney, gastric tumors (greater curvature), volvulus of the small intestine, large bowel neoplasms, mesenteric growths, congenital anomalies and many others.

Brief reference to the embryology, simple anatomy and physiology discloses several factors to which many of the erroneous diagnoses in this tumor group may be attributed.

Both tube and ovary, arising from the same embryonal cell mass, develop mutually, progressively and in intimate association. They are integrated into a structural and functional unit by connecting folds of peritoneum, the mesovarium, the mesosalpinx, the infundibulo-pelvic and the utero-ovarian ligaments. These serve not only as common, fixed supports and cohesive links but also provide for spontaneous changes involving rotation, displacement and movement, by virtue of their suspensory, elastic, tenuous and pivotal characteristics. The embrace of the ovary by the distal portion of the Fallopian tube and the fimbrial attachments to the upper pole of the ovary (extremitas tubaria) are supplementary evidences of this complete unity. Furthermore, the similarity in the sources and distribution of their vascular, neurologic and lymphatic networks adds to the already strikingly common pattern of close relationship of both structures.

Thus, it is not difficult to understand why the tube and ovary, mutually inte-

grated, exhibit a functional reciprocity in the physiological mechanism of ovular migration; or why changes in size, shape and position of the ovary, due to ovarian tumors, for example, will be reflected in the corresponding Fallopian tube by elongation, modified course and displacement; or, finally, why, under conditions of disease or growth, these closely related structures produce coalescent or confluent masses, rather than separate, demarcated and easily distinguished tubal or ovarian entities.

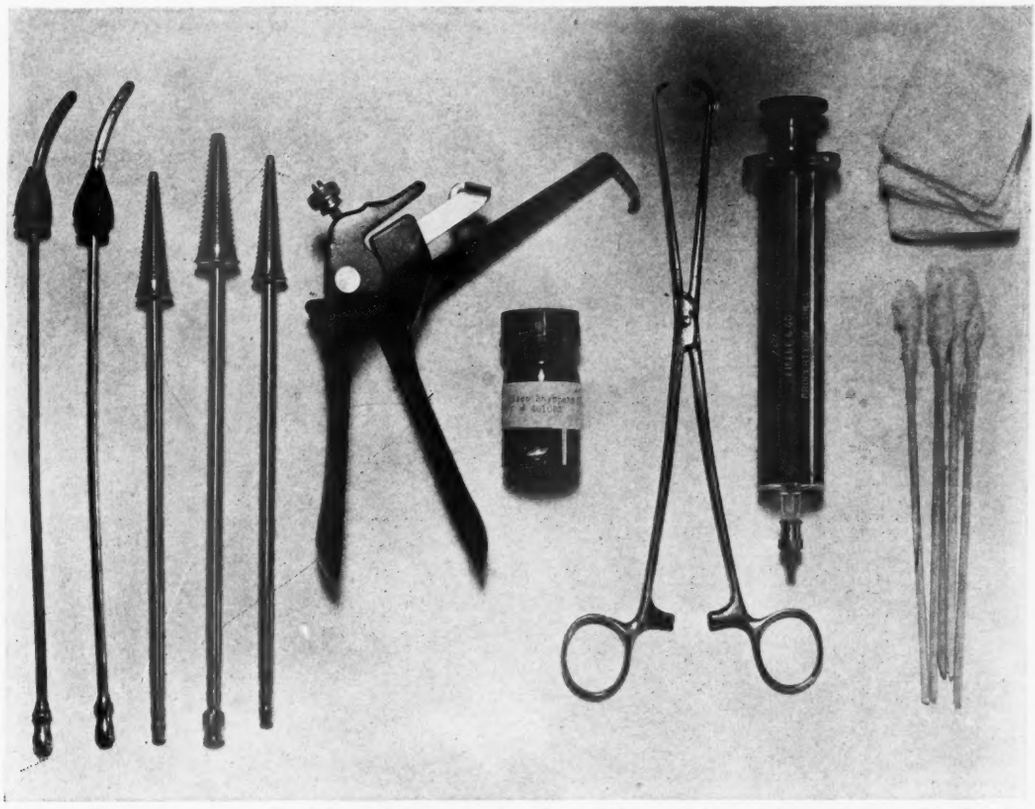

FIG. 1. Instruments required for salpingography; from left to right, perforated cannula, Colvin screw cannula, non-opaque speculum, Viscorayopake, tenaculum and 20 cc. syringe with adapter.

The shortcomings of bimanual examination, clinical history and laboratory findings, and the evident anatomical and physiological unity of the adnexal structures explain the principal bases upon which errors in diagnosis are made. In view of the foregoing considerations, it would seem that the Fallopian tube, because of its unique anatomic setting and possibilities for *x*-ray visualization, could serve as a graphic index of changes occurring in adjacent structures. Thus, salpingography, supplemented when desired, by stereoscopic studies, has proven to be a valuable aid in the visualization of adnexal masses, and warrants more widespread use. This simple *x*-ray test has proven safe, rapid and inexpensive.

With spectacular certainty, it may determine by tubal outline not only the pelvic origin of an obscure abdominal mass (Fig. 4), but, conversely, may confirm (by normal tubal *x*-ray shadow) the presence of an abdominal tumor in the pelvis. The synthesis of an obscure and confluent tubo-ovarian mass may be better understood if, around the tubal component visualized by *x*-ray, its ovarian element may be reconstructed (Fig. 10) to fit the clinical pelvic findings. Thus, by the tubal shadow determinant, the exact extent of either ovarian or tubal growth with relation to the adnexal mass as a whole, may be ascertained. Intra-

tubal carcinoma (Fig. 4), although rare, may be also detected by the irregular shadow characterized by moth-eaten, bizarre patterns within the tubal wall, not unlike that observed in uterine cavity malignancy. (Fig. 4.) Differential diagnosis between a uterine and ovarian growth (Fig. 11) is very often simplified by visualization of a displaced or extrapelvic tubal shadow, produced by traction or pressure, incidental to ovarian enlargement. Not infrequently also, the presence of intraligamentous growths (ovary, uterus, cervix or paroophoron) due to their symmetrical and upward pressure on the superposed tube, may be confirmed by a linear tubal shadow of smoothly arched convexity. Thus, the *x*-ray details of position, course, curvatures and torsion reflected in the tubal shadow may serve to outline the contour, size and position of contiguous tumors. (Figs. 7, 9 and 11.)

With the aid of stereoscopy, a three dimensional shadow is projected. This establishes not only a spatial relationship of the tumor with the bony pelvis and adjacent pelvic viscera, but also often defines the lobulations, direction of growth (Fig. 9) and size of the mass involved. Further information and verification is often obtained by contrast with genito-urinary tract and lower bowel *x*-rays.

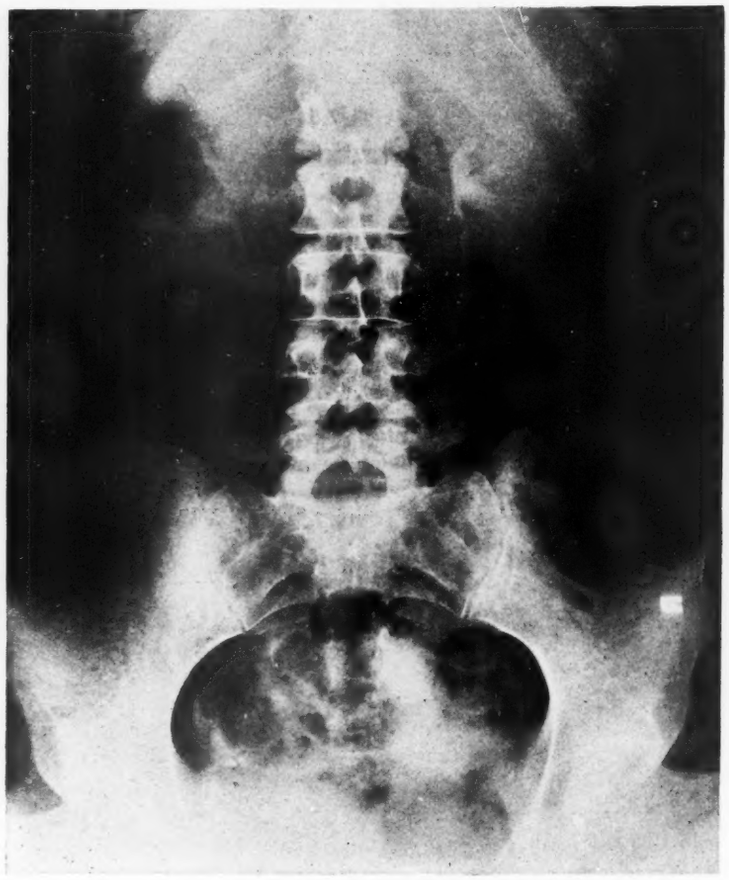

Fig. 2. *X*-ray evidence of bilateral excretion of Viscorayopake, thirty minutes after intrauterine injection. Note unabsorbed residuum still in pelvis.

Salpingography, in recent years, has become a rapid and simple office or hospital procedure, and has achieved sufficiently uniform success to take its place among the accepted tests employed in surgical diagnosis. Its uses in the study of sterility and in the determination of tubal patency in conjunction with the

Rubin insufflation test (and its use in visualizing intrauterine growths by cavity distortion) have been described in the literature.[17,23,24]

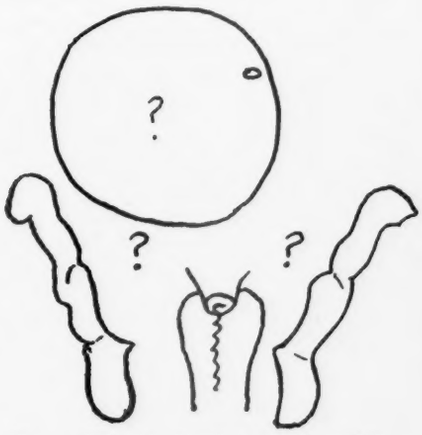


FIG. 3. Sketch of pelvic findings (Case 1) showing obscure mass in left lower abdomen. No pelvic structures palpable except bleeding cervix. Relationship between mass and genitalia not determined.

Since 1910, rapid advance in roentgen visualization of the pelvic viscera has been made by a number of workers.[1,2,4,5,6,7,8,12,13,15,25] These authors have contributed to our present knowledge by their experiences with various radiopaque media, methods of introduction and technic of radiography. The principal retarding factor confronting all these investigators was the inadequacy of the many opaque substances heretofore used. Such shortcomings as tissue irritation, insufficient opacity, unsatisfactory viscosity, toxicity, slow absorption and chemical instability were common to one or another of the substances used.

The recently introduced fluid substance, Viscorayopake* has eliminated these objections and appears finally to have satisfied the requisites of an ideal opaque *x*-ray medium. As observed in the roentgen films, its renal excretion begins quickly. The dye may be observed in the kidneys and ureters (Fig. 2) within thirty minutes of intrauterine instillation, even while the pelvic shadows are still present. The renal shadows usually persist until the pelvic dye is completely absorbed, but often may disappear before this point. From serial studies of pelvic and renal tract shadow intensity, it may be concluded that the rates of pelvic absorption and renal excretion in the same patient are roughly proportional. These factors, however, may vary in different individuals because variations in peritoneal absorption and renal threshold undoubtedly play an important rôle. The complete disappearance of Viscorayopake* takes place rapidly.

FIG. 4.—Hysterosalpingogram (Case 1) showing shadow defects along right uterine wall suggesting malignancy; and rarely observed type of left tubal shadow, elongated, dextroverted, distally enlarged French horn type, containing shadow defects indicating neoplasm.

In the diagnosis of the adnexal tumor, the technic employed is similar to that used for hysterography which has been previously published.[24] In view of certain changes particularly essential for the delineation of tubo-ovarian masses only, it

* Chemical structure: Diethanolamine salt of 2,4,-dioxo-3-iodo-6 methyl tetrahydropyridine acetic acid. Three and one-half per cent concentration of polyvinyl alcohol is added to procure satisfactory viscosity.

* Viscorayoke was furnished by Hoffman LaRoche, Nutley, New Jersey. The clinical use of this chemical was first described by I. C. Rubin in 1941, from the Mount Sinai Hospital in New York City.

is presented with revision and in somewhat briefer form.

*Method.* The patient, who has taken 2 dr. of licorice powder the night before, and an enema two hours before the test, is examined bimanually, in the lithotomy position, on a Squier genitourinary table, in order to determine the cervico-uterine angle (for the direction of the canal). Asepsis is carried out by vulvovaginal cleansing with soap and water and the use of sterile drapes.

FIG. 5.

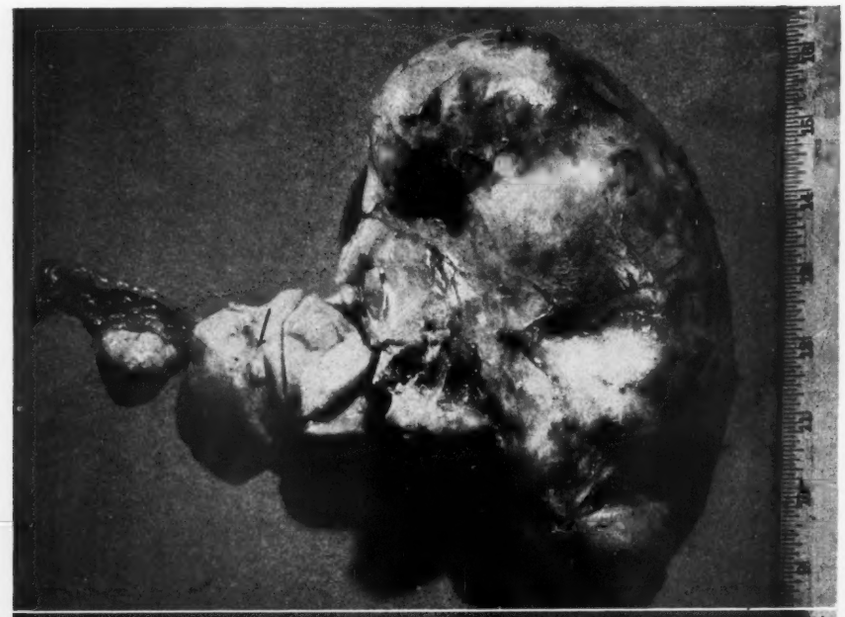

FIG. 6.

FIG. 5. Specimen (Case 1) showing right uterine wall carcinoma and enormous left tubal carcinoma. Note similarity in size, course, displacement, elongation, etc., of specimen with the tubal shadow in Figure 4.

FIG. 6. Cross section of solid tubal carcinoma (Fig. 5), with early signs of hemorrhage, liquefaction and aseptic necrosis.

A non-opaque bivalved speculum is used to expose the cervix, the external os of which is wiped dry and painted with tincture of iodine.

A 20 cc. syringe containing 15 cc. of Viscorayopake is fitted with a Luer metal tip and connected to either a uterine stem perforated cannula, as used in the Rubin test, or, to a Colvin[16] cervical stainless steel cannula. (Fig. 1.) The latter has proven especially satisfactory in preventing backflow, where a wide cervical canal is encountered. After displacing the air from the syringe and also from its contained dye substance (air bubbles may cause errors in diagnosis), the cannula is inserted into the external os in the direction of the cervico-uterine axis until the perforated tip lies within the cavity. When the Colvin screw tip cannula is used, simple rotation effects entry. Grasping the cervix with tenaculum forceps is a painful procedure, and unnecessary except in cases requiring traction for better cervical exposure, for an obstructive cervix, or where counter-pressure is required to prevent leakage.

The patient's pelvis is placed in proper alignment with the *x*-ray tube and plate. Ordinarily, 50 milliamperes and 58 primary volts for a two-second exposure, with a focal plate distance between thirty and thirty-six inches is ample. A flat plate, or scout film, is first taken in order to exclude phleboliths, calcified lymph nodes, unabsorbed radiopaque substances such as lipiodol used in previous tests, or intragluteal bismuth residue.

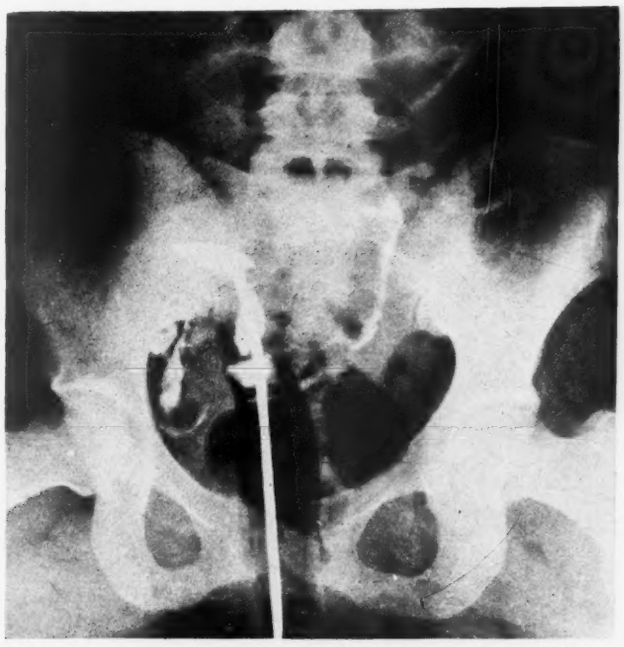

Fig. 7. *X*-ray showing left tubal semilunar shadow (Case 11) due to the effect of a contiguous ovarian cyst. (Fig. 8.)

From 4 to 6 cc. of Viscorayopake are then injected, very slowly, intermittently and cautiously, with light or moderate pressure, in order to avoid uterotubal spasm. While the film is being taken, firm pressure is maintained on the piston of the syringe, in order to prevent leakage. After the patient is *x*-rayed, variable quantities of the dye may be suctioned back. With uterotubal blockage, very often all the chemical may be recovered. The wet *x*-ray film may be inspected immediately. On rare occasions, tubal obstruction or closure is diagnosed when tubal shadows are not found. In these cases, I have found it advantageous to repeat the test using a still slower rate of injection. Often complete tubal patency is revealed in these subsequent tests. Too rapid injection may cause hypertonicity and irritability, producing bilateral sphincteric spasm in the uterotubal muscle, thus preventing access of the dye into the Fallopian tube.

The patient usually described varying degrees of discomfort in the central suprapubic region, which radiates laterally as the fluid advances correspondingly along the tubal canal. Contact with the pelvic peritoneum not infrequently gives rise to generalized lower quadrant pain or discomfort, but many patients complain of no pain whatsoever. These signs are fairly reliable in predetermining not only the site of partial or complete obstruction, but also in ascertaining tubal patency.[22]

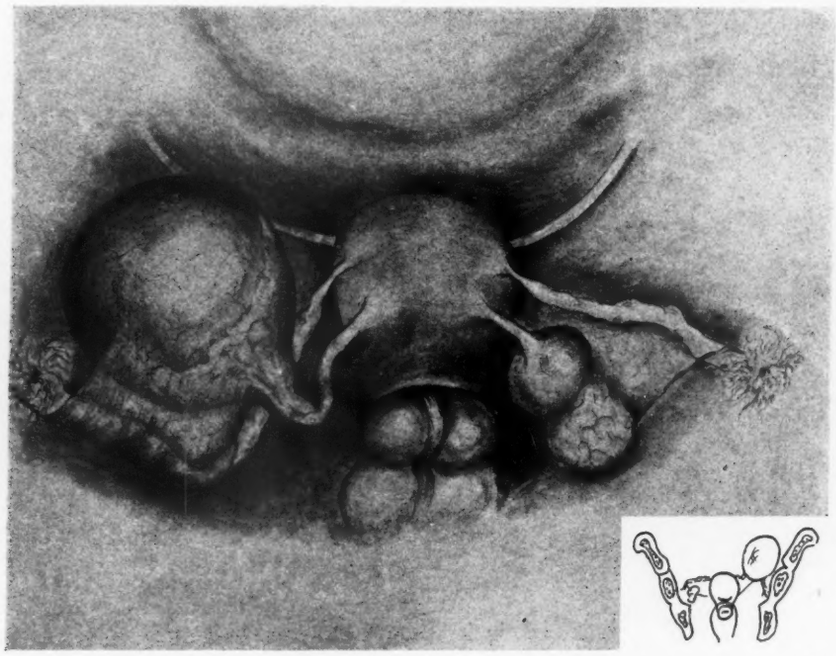

FIG. 8. Drawing showing operative findings of left tube deviation due to left ovarian cyst corresponding to salpingogram in Figure 7. Inset sketch indicates preoperative findings.

Within fifteen minutes of the last injection, the patient may sit up and usually is immediately ambulatory. Transitory nausea, vomiting, discomfort, or mild pain occur in about half the patients. Severe reactions occur rarely. Petit mal was noted in two patients who had a history of childhood convulsions and syncope.[24] Recovery in both instances was immediate and there were no sequellae. When nervousness or apprehension is encountered, the use of mild sedation in preparation for the test is worthwhile.

Moderate uterine bleeding is not strictly a contraindication, but it is wise to defer the test until active bleeding, incidental to the menses or any other cause, has subsided. During the interval phase of ovulation, the six-month postpartum period, or for thirty days after surgical procedures, salpingography may likewise be postponed.

Among other contraindications to the test are acute pelvic infections, acute endocervicitis, gonorrhea, intrauterine or ectopic pregnancy and cervical carcinoma. Epilepsy, petit mal, hysteria and psychoneurosis may be considered conditions which are unfavorable and possibly hazardous.

Sedation and smooth muscle anti-spasmodic drugs in small doses have been found useful in preventing uterotubal spasm which may occur in markedly nervous women, or due to sphincter irritability induced by a too rapid introduction of the fluid medium.

In order to describe and emphasize important differential criteria, brief case histories are presented in connection with examples of diagnosis by salpingography.

## CASE REPORTS

The following presentation illustrates three diagnostic features: (1) differentia-

tion between abdominal and pelvic tumors, (2) identification of the pelvic origin and, (3) the type of tumor.

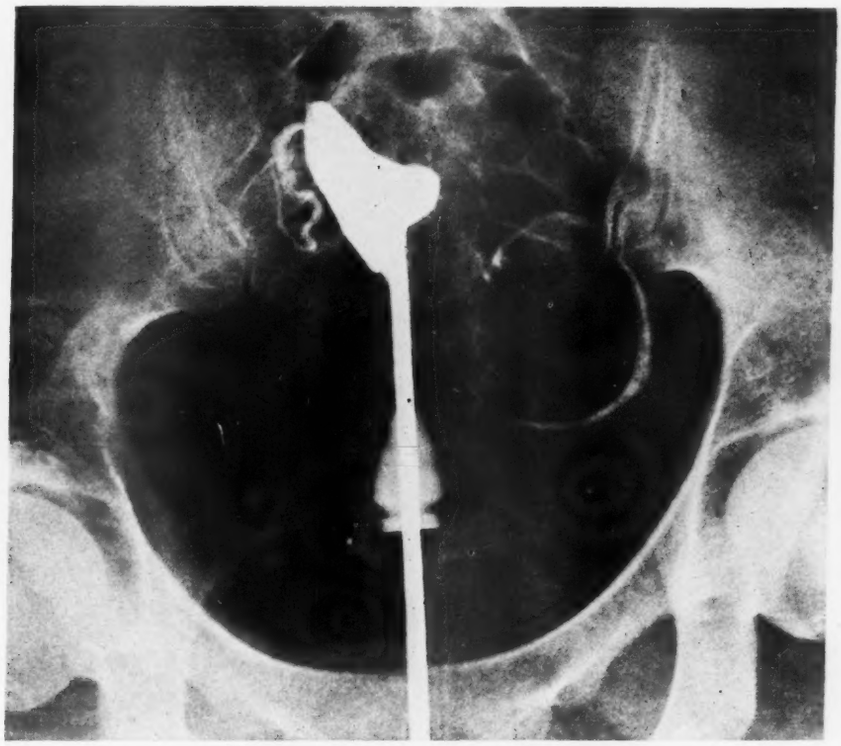

Fig. 9. Salpingographic evidence in an unreported case of a right ovarian cyst. Stereoscopically, the tube is found to course posteriorly and downward, then forward and laterally underneath the cyst, which is encircled in its ascending portion.

Case 1. Mrs. L. A., a fifty-eight year old housewife, visited our out-patient department on May 17, 1943, complaining of alternating watery and bloody vaginal flow, which began in 1941, after one year of menopause. Increased girth and weight (114 to 210 pounds), ankle edema, precordial pain and dyspnea, and urinary incontinence were additionally noted. The menstrual cycle had been normal. Sterility since 1923 followed delivery of a stillborn by forceps. Except for influenza in 1918, there were no illnesses.

Between July 8 and December 29, 1942, she was observed at another Naval Hospital for vaginal bleeding, an abdominal mass and heart disease. Curettage performed on December 12, 1942, under low spinal anesthesia (10 mg. pontocaine in glucose) revealed "a normal symmetrical uterine cavity, four inches in length" and "hyperplastic endometrium and small pieces of hemorrhagic and white tissue." After complete clinical and *x*-ray studies she was discharged without further surgery with a diagnosis of hypertensive heart disease and abdominal tumor of undetermined origin.

Our physical examination revealed a florid, obese, myxoedematous female of broad, short stature with moderate facial hirsutism, edentulous gums, bilateral gynecomastia and a markedly pendulous abdominal wall. The pulse, temperature and respirations were normal. The history of decompensation, the hypertension (200/94), the apical systolic murmur and our *x*-ray and electrocardiographic evidence of myocardial disease confirmed the discharge diagnosis of "hypertensive heart disease with relative coronary insufficiency." The lungs were clear.

Through the thick, adipose panniculus, a large, globular, fixed tumor was vaguely outlined in the right lower quadrant. A fluid wave was not demonstrable. An abdominal scout film showed "no definite tumor mass," while barium enema *x*-ray plate showed the "rectosigmoid colon displaced mesially."

Pelvic examination disclosed a parous, scarred, and thin perineum and a retracted,

atrophic and fixed cervix, which reflected no effects from traction or pressure upon the abdominal mass. (Fig. 3.) The lower extremities were normal except for ankle edema and generalized varicosities.

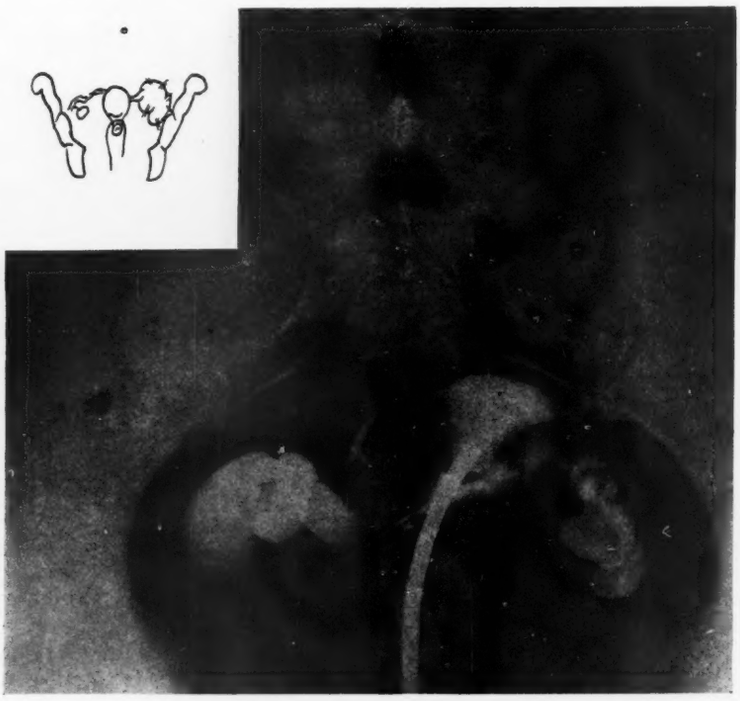

FIG. 10. Salpingogram (Case III) indicating left hydrosalpinx and right chronic salpingitis, unanticipated because complete study and history of patient was negative. Inset sketch shows preoperative unilateral findings which suggested adenomyosis.

Laboratory tests including urine and blood examinations, Kahn test, non-protein nitrogen blood level and sedimentation rate were within normal limits.

Hysterosalpingography performed in the presence of moderate bleeding, with Viscorayopake, revealed (Fig. 4) a symmetrical enlarged uterine shadow with an irregular, mottled defect along the right border, characteristic of malignancy. The right tube was not visible. The left tube rose completely out of the true pelvis, and ascended contralaterally to the level of the right iliac crest, where, turning sharply downward, it broadened gradually, then markedly, in its distal portion, somewhat like a French horn. In the latter area, numerous moth-eaten defects suggested a silhouette, characteristic of carcinoma.

Because of the poor operative risk (cardiac disease, obesity, varicosities and age), surgery was deferred until her general condition improved and she had decreased her weight by forty pounds.

At operation, at the Newport Hospital, on September 24, 1943, under nupercaine spinal anesthesia, the left tube was found to be enormously enlarged and transformed into an intact, squash-shaped tumor, nine inches long and four to five inches wide. Dense adhesions to the cecal colon and bladder fixed it firmly in the right pelvis.

The uterus and both adnexae were removed. On opening the specimen, a solid tubal carcinoma and two areas of malignant growth in the uterine cavity were grossly observed. (Figs. 5 and 6.) Microscopically, adenocarcinoma was reported in the left tube and in the uterus.

The patient made an uneventful recovery. She refused both *x*-ray and radium therapy, and, when last seen, one year after operation, had no clinical evidence of metastases.

Because of the variance of our uterine findings with those of the curettage performed only nine months prior, the original microscopic slides were requested. These showed definite uterine adenocarcinoma. Accompany-

ing the microscopic slides was a corrected diagnosis confirming this fact.

The following case illustrates *x*-ray diagnosis of ovarian cysts by means of the tubular shadow.

Fig. 11. Salpingogram (Case iv) showing extrapelvic ascent of right tubal shadow verifying ovarian origin of tumor.

Case ii. Mrs. C. B., aged twenty-two years, married two years, complained of left lower quadrant pain, radiating to the opposite side, which increased after coitus, exercise and at menses. There was occasional resultant nausea. A three-month interval oligomenorrhea, which characterized the cycle since a delayed onset at fifteen years, was replaced by normal periods after marriage. The family history was irrelevant. The patient recalled no illnesses or somatic symptoms and had gained eight pounds in the past two years. Kahn test, blood count and urine examinations, sedimentation rate and chest *x*-ray were normal.

The physical findings were entirely normal except for a movable orange-sized cyst of the left ovary. (Fig. 8 inset.) Flat plate of the pelvis failed to reveal calcific elements of a dermoid cyst. Salpingography (Fig. 7) revealed an outline of the left tube coursing upward in semicircular curve conforming to the surface of its attached ovarian growth.

At operation in the Newport Hospital, June 16, 1944, a tennis ball-sized cyst was excised from the left ovary. (Fig. 8.) The pathological diagnosis was simple ovarian cyst.

The accuracy in the identification of origin and pathology of an obscure adnexal mass, in the absence of helpful clinical or laboratory data is next shown.

Case iii. Mrs. M. I., aged thirty-two years, married nine months, complained of headache, dyspnea, weakness, a three-week menstrual cycle with dysmenorrhea, constipation, diarrhea or bloody stools and a forty pound weight gain. An appendectomy (1933) and a cholecystectomy (1939) were performed at the Truesdale Hospital, Fall River, Massachusetts. There were no other symptoms referable to pelvic disease and no history of venereal infection.

Examination revealed a tall, overweight, phlegmatic, myxoedematous, ill appearing individual with stooped posture. Physical

abnormalities and laboratory findings, including complete blood count, urinalysis, sedimentation rate and Kahn test were normal. *X*-ray of the chest and cranial sinuses showed no rhagia and a suprapubic mass of two months' duration. She was discharged from the hospital by her physician with a diagnosis of fibroids of the uterus.

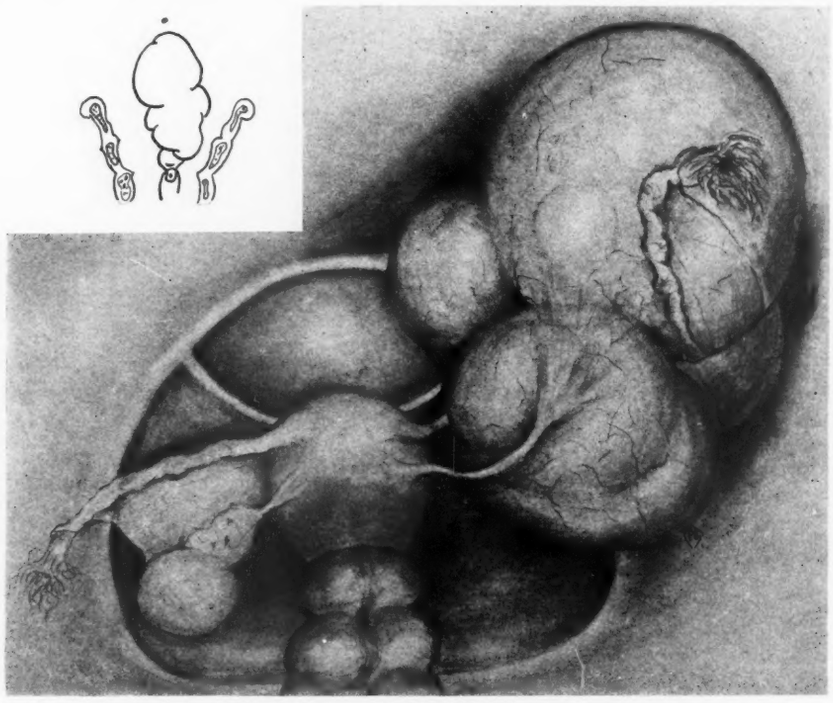

FIG. 12. Drawing of operative pathology (Case IV) showing tube ascending and partially encircling a right ovarian papillary serous cystadenoma. Note correlation of tubal shadow in Figure 11 with operative findings. Inset shows sketch of preoperative findings.

evidence of infection. The basal metabolic rates were −22 and −25 per cent.

Pelvic bimanual examination (Fig. 10 inset) revealed an irregular, resistant, non-tender, fixed, left adnexal mass. The fundus was retroposed, small and tender. The right adnexae were not felt. The cervix showed no erosions, and on movement, caused no pain. A mucopurulent discharge suggested endocervicitis but several endocervical smears revealed no gonococci. Both preoperative diagnoses, adenomyosis or ovarian tumor, which generally call for surgery, were rejected in view of the *x*-ray findings.

The salpingogram (Fig. 10) with Viscorayopake medium indicated bilateral tubal disease and left hydrosalpinx.

Correct differential diagnosis between uterine, tubal and ovarian masses is illustrated by the last instance.

CASE IV. Miss D. W., a twenty-one year old student nurse, complained of menometror-

Her history, complete blood count, urine findings, sedimentation rate and Kahn test were all within normal limits. Physical examination revealed no somatic abnormalities except for a globular, irregular, resistant, immobile, suprapubic mass reaching one inch above the umbilicus. (Fig. 12 inset.) Its lower pole seemed confluent with an unenlarged, retroposed uterus. The left adnexae appeared normal. The cervix was normal and found high up in the vaginal vault behind the pubis. A diagnosis of ovarian cyst was made. Hysterosalpingography revealed the right Fallopian tube ascending to the level of the fifth lumbar body in the midline. *X*-ray diagnosis: extrapelvic ovarian cyst. (Fig 11.)

After readmission to the Newport Hospital, she was operated on March 30, 1943, under gas-oxygen-ether anesthesia. A large, extrapelvic, multilocular, right ovarian cyst was found. (Fig. 12.) The right tube spiralled directly upward over the tumor, forming an

incomplete arc. There were no adhesions or points of rupture in the cyst wall.

A right oophorectomy was performed, care being exercised to preserve the integrity of the contiguous Fallopian tube.

Follow-up hysterosalpingography revealed bilateral tubal patency.

## SUMMARY

1. Both gynecologists and surgeons recognize the difficulties and shortcomings in the diagnosis of the adnexal mass.

2. The interdependant anatomic relationship between the tube, ovary and their supporting structures most frequently is the direct cause of this problem.

3. Because of this close unity, the structural and kinetic changes which take place in the adnexae are often reflected by the Fallopian tube. *X*-ray visualization of the tube, therefore, furnishes a unique index, by which various types of adnexal disorders may be distinguished.

4. Salpingography serves to: (1) differentiate between uterine and ovarian tumors, (2) distinguish intraligamentous growths, (3) determine whether a mass is of pelvic or abdominal origin, (4) delineate ovarian tumors as to their size, position and contour, (5) establish, in the confluent adnexal masses, by exclusion, the size of the ovarian component, as well as the visualized tubal elements, and (6) diagnose chronic tubal disease, new growths and partially or completely obstructive tubal masses.

5. Viscorayopake has proven to be an ideal medium for pelvic *x*-ray. It is excreted rapidly by the kidney.

6. Contraindications to salpingography are stated.

7. Four cases and the pelvic *x*-rays of each are presented to illustrate various differential diagnoses, made possible by salpingography.

8. The method is simple, rapid and innocuous; and is suitable for use in a hospital or any properly equipped office. This test lends itself successfully to the differential diagnosis of the adnexal tumor and has proven so successful that its more widespread use is recommended and anticipated.

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# INTESTINAL INJURY AND FECAL FISTULA IN GYNECOLOGICAL SURGERY*

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THE small or large intestines may be injured during any gynecological laparotomy. An injury occurs most often on separating adhesions found between the intestines, the pelvic viscera and the abdominal wall. These adhesions may be the result of pelvic inflammatory disease or previous operations. This is shown by the high incidence of fecal fistulas following surgery for pelvic inflammatory disease. MacLaren[1] reported seventy-seven cases of intestinal fistulas in a series of 1,500 major abdominal operations; forty followed gynecological surgery, of which twenty-two were associated with ovarian abscesses, sixteen with tubal tuberculosis, and two with pyosalpinx. In a series of 155 fecal fistulas reported by Mayo and Schliche,[2] twenty-five followed laparotomy for pelvic inflammatory disease. Rankin, Bergen and Buie[3] reported forty-four out of 264 cases of fistulas and Ginzberg[4] reported ten in a series of sixty-two fistulas.

There were forty-two cases of intestinal injury from 1928 to 1943 on the Gynecological Service of Harlem Hospital, where more than 80 per cent of the patients operated upon have some degree of pelvic inflammatory disease. During this period of sixteen years, 5,055 laparotomies were performed. The known incidence of intestinal injury was, therefore, 0.83 per cent.

The intestines may be injured on opening the peritoneal cavity. This type of injury, as a rule, is detected and repaired immediately. Such accidents are more common in patients who have had a previous laparotomy. In this series there was only one such case. No fistula followed. The bowel may also be lacerated in cutting across the vagina in a total hysterectomy if the rectum is adherent to the posterior wall of the cervix. There was no such accident in this series. Injury to the intestines may also occur in separating adhesions between two loops of bowel, the intestines and pelvic organs, or between the intestines and the abdominal wall.

Two types of adhesions were found, depending upon their origin:

1. *Those Caused by Previous Laparotomy.* In some patients who have had previous laparotomy the intestines and omentum may be firmly matted together with the pelvic organs. These adhesions may be very difficult to separate. In one patient, following a previous laparotomy in which both tubes and the right ovary had been removed, a cystic left ovary was found "cemented" in between the broad ligament and the rectum. Injury to the latter was not recognized and a fecal fistula developed.

In others, the skin, fasciae, peritoneum and intestines may be fused in one thick sheet in which distinct layers or planes are difficult to identify. In cutting through the thinned out fascia and muscle, the peritoneal cavity may be inadvertently opened as a definitive peritoneal layer may be absent. If the intestine is adherent to the abdominal wall it may be readily traumatized. Meticulous dissection on opening the abdomen in a patient who has had a previous laparotomy will prevent intestinal injury.

2. *Those Caused by Disease.* Patients with pelvic inflammatory disease of gonor-

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rheal origin have few adhesions except to the fimbriated end of the tube. The adhesions between the intestines and the tubal wall are usually friable, thin and flimsy and easily separated. At the fimbriated end of the tube where the pus has spilled into the cul-de-sac, the adhesions between the sigmoid, tube and posterior wall of the broad ligament are very dense. Here the separation is usually done blindly (without vision) and the large bowel may easily be injured, an injury which may not be recognized. There were seven such cases of injury in which the sigmoid was densely adherent to a tubo-ovarian abscess or pyosalpinx.

Tubo-ovarian abscesses were present in thirteen patients in this series, four of which were ruptured during the operation. In eleven patients the pelvic viscera and intestines were so adherent that long and difficult dissection was necessary to identify the uterus, tubes, ovaries, intestines and bladder.

Usually the intestinal injury is seen and recognized at the time of operation. There were, however, many cases in which the intestinal trauma ultimately caused necrosis of the bowel, but no injury was recognized at the time of operation. As a result, a fecal fistula or fatal peritonitis occurred postoperatively.

The type of injury to the intestines may be classified as follows: (1) Laceration to the peritoneal coat or serosa and musculature; (2) laceration into the bowel lumen; (3) laceration across the entire diameter of the bowel; (4) internal fistulas (spontaneous) between intestines or appendix and the pelvic viscera, and (5) latent injury not recognized at operation, but later manifesting itself by a fecal fistula or a fatal peritonitis.

In pelvic inflammatory disease of pyogenic or tuberculous origin, in degenerated or infected fibroids, endometriosis, ovarian and tubo-ovarian abscesses, and in malignancies, the adhesions encountered are very dense. In separating these adhesions to isolate the pelvic structures, the intestines are easily injured.[5]

If patients with pelvic inflammatory conditions are operated upon too early, not only are the adnexae still inflamed, but the intestines are infiltrated, soft and friable. As the acuteness of the infection subsides, the exudate in the intestinal wall is absorbed and the adhesions can be separated more readily.[6]

It is important, therefore, that some criteria be established to determine when the acute infection has subsided.

Falk,[7] quoting statistics of mortality and morbidity of salpingectomy from the literature, found that the mortality rate varied from 1 to 10 per cent. The most important factor resulting in a high mortality was operation during the acute stage. The reports of operative morbidity also varied from 5 to 52 per cent, again determined by the acuteness of the inflammation.

Simpson,[8] in 1907, emphasized the value of deferred operation for the removal of pus tubes. He used the following four criteria to determine the time of operation:

"First, the patient's general health must be such that she has a good margin of reserve strength.

"Second, there must be no cellular exudate. If one existed, it was nature's positive declaration that the offending structure contained a poison she was afraid to admit into her systemic circulation. When the need for its existence disappears, an exudate is always absorbed. We can well afford to wait until that time.

"Third, the temperature must be absolutely normal, or lower, for at least three weeks—at first an arbitrary period, which I think has proven to be the earliest uniformly safe time to operate.

"Fourth, when the preceding have been demonstrated to exist, a careful bimanual examination is made and the temperature is taken every hour for four hours; if this slight traumatism causes a rise in temperature, we may be sure that the greater injury due to the operation would very likely cause a serious inflammatory reaction."

Although Simpson's rules were followed, cases were frequently seen in which despite preoperative bed rest and supportive therapy for as long as two months, extensive exudate and adhesions with friability of the intestinal wall were found at operation. This occurred in spite of an absence of fever or leucocytosis for more than three weeks. It was therefore deemed advisable to add the sedimentation rate of the red blood cells to our criteria.

The Linzenmeir method for determining the erythrocyte sedimentation rate was used. The Linzenmeier values are expressed in the number of minutes required for sedimentation to reach 18 mm. In most other methods the final reading is expressed in millimeters of settling in a standard period of time.[9,10]

Although the normal sedimentation rate is generally considered to be one hour (Linzenmeier method), at Harlem Hospital thirty minutes has been considered the operable index for surgery, particularly in those patients who had been in the hospital for many weeks and appeared clinically ready for surgery.

Of the eighteen cases of fecal fistulas, there were only four cases in which the sedimentation rate was longer than thirty minutes. In nine cases the preoperative sedimentation rate was thirty minutes or less. In the remaining five cases, there was no record of a preoperative sedimentation rate, but the admission sedimentation rate was less than thirty minutes.

The rapid sedimentation rate would seem to indicate a residual acute inflammatory process which cannot be detected clinically.

The forty-two cases of intestinal injury may be divided as follows:

A. Injury detected and repaired during operation—without fecal fistula formation —twenty-two cases.

B. Injury detected and repaired at operation—with the development of fecal fistula—three cases.

C. Injury not detected at operation—with resulting fecal fistula—fifteen cases.

D. Injury not detected at operation—with resulting peritonitis and death—two cases.

*A. and B. Injury detected and repaired during operation—twenty-five cases:* In twenty-five, or 59.5 per cent, of the total number of forty-two cases, injury to the intestines was detected and repaired during operation. The intestinal damage in the twenty-five cases was as follows:

Laceration of the serosa—14
Laceration into the bowel lumen—5
Laceration across the bowel—3
Spontaneous intestinal fistula—3

It is significant that regardless of the type of severity or intestinal injury, neither fecal fistula or peritonitis occurred in twenty-two, or 88 per cent, of the twenty-five cases in which the injury was recognized and repaired at the time of operation. The prognosis in intestinal injury is largely dependent upon this recognition and repair at time of operation. Since unrecognized injury leads to fecal fistula or fatal peritonitis, immediate and proper repair is essential.

In three cases, or 12 per cent, fecal fistulas developed, although the injury to the intestine was discovered and repaired at operation. Two occurred after a serosal tear and one, subsequent to a tear into the lumen of the bowel. The latter was sustained in separating a cystic ovary from between the posterior leaf of the broad ligament and the rectum. Difficult sharp dissection was necessary as the adhesions were particularly dense from a previous bilateral salpingectomy and right oophorectomy. The admission sedimentation rate was only 8 mm. in one hour. Drainage was ample with three Penrose drains to the site of intestinal repair and two to the lumbar gutters with gauze drainage vaginally. Despite low sedimentation rate, adequate repair of intestine and ample drainage, the patient developed a fecal fistula.

*C. Injury not determined at operation—resulting in fecal fistula—fifteen cases:* In

fifteen, or 83 per cent, of the eighteen cases of fecal fistula, intestinal injury was not recognized at operation. In this group, dissection was difficult due to extensive adhesions. Bleeding usually was active and may have been a factor in masking the intestinal injury. No obvious tear or perforation of the intestine was seen. Though no injury was evident at the time of operation, impairment of the blood supply with necrosis of the damaged area resulted in a "blow-out" in the form of a fecal fistula, a fortunate outcome.

*D. Generalized peritonitis following undetected intestinal injury—two cases:* Inclusion of these two cases of a generalized peritonitis makes a total of seventeen cases of unrecognized intestinal injury. Fistula formation did not take place and the leakage of intestinal contents into the peritoneal cavity resulted in generalized peritonitis.

Case I. D. S. was operated upon for fibromyoma uteri. A supracervical hysterectomy was done with separation of dense adhesions. At autopsy, a perforation of the sigmoid with general peritonitis was found.

Case II. L. M. had a supravaginal hysterectomy and left salpingectomy. Adhesions between the uterus, adnexa and intestines were separated with difficulty. The abdomen was not drained. On the fourth postoperative day the patient became acutely ill with abdominal distention, rapid pulse and fever. She died on the ninth postoperative day of an overwhelming generalized peritonitis. Postmortem revealed a generalized fecal peritonitis with three perforations of the small intestine about ten feet above the ileocecal junction.

## TREATMENT OF INTESTINAL INJURIES AT OPERATION

Repair was accomplished by two to three rows of locked, interrupted or continuous-running sutures of No. 00 chromic or Pagenstecher.

If the serosa alone was lacerated, it was approximated with a continuous No. 00 chromic suture on a fine intestinal needle. When the intestinal wall was infiltrated and thickened, it was necessary to pass interrupted sutures of No. 00 fine chromic deeply in order to include the submucosa, which is the strongest layer. A second layer of sutures through the serosa was applied following the approximation of the muscular layer. If the injury was down to the lumen, the muscular wall was closed with interrupted sutures followed by two additional layers of sutures. In recent years, 10 Gm. of a sulfonamide were placed into the pelvis and over the repaired area.

In those cases in which the bowel wall is so thick, friable and non-yielding that the edges cannot be brought together, Bonney[11] suggests the following four procedures: (1) Attaching the bowel to the anterior abdominal wall by means of a circular stitch, tying it not too tightly so that the sutures may not tear through the bowel. (2) Suturing the opening in the bowel to the wall of a neighboring coil of gut. (3) Suturing the intestine to the wall of the uterus to close the perforation. (4) Suturing the omentum over the area, being careful not to have too much tension on the transverse colon.

If the large intestine is completely torn across, as occurred in one case, an attempt should be made to do an end-to-end anastomosis. If unsuccessful, a permanent colostomy is established through a stab wound in the left side of the abdomen and the lower loop of the bowel closed.

## EFFECT OF DRAINAGE FOLLOWING INTESTINAL INJURY

All three cases of fecal fistula which followed intestinal injury were drained. In two, the serosa alone was involved; in the other, there was a small perforation of the intestine. Conversely, in other patients with more extensive trauma, no fecal fistula developed despite lack of drainage.

Of the fifteen cases of fecal fistula following unrecognized injury, nine, or 60 per cent, were drained, six through the abdomen and three by colpotomy.

On the other hand, of twenty-two cases of recognized and repaired intestinal injury

thirteen, or 59 per cent, were drained as follows: abdominal eight, colpotomy three, abdominal and vaginal drainage two. Of the two patients who developed peritonitis, one was drained and one was not.

From the above, it would seem that drainage of any type does not play an important rôle in the prevention of fecal fistulas or peritonitis. Recognition and thorough repair are more important.

### CLINICAL SIGNS AND DIAGNOSIS

The location of the intestinal fistula determines the symptoms and signs present. The more distal the opening in the intestine is from the duodenum, the less marked are the symptoms and signs. In the low intestinal fistula encountered following gynecological surgery, there is not the loss of pancreatic and intestinal secretion with the marked irritation of the skin caused by the digestive action of the intestinal juices found in high intestinal fistulas.[12]

The prodromal signs of fecal fistulas vary. Abdominal distention and fever usually precede local signs. In most cases there seemed to be, at first, a simple wound infection with, generally, a foul, purulent discharge. The diagnosis was not usually suspected until fecal contents appeared on the dressings.

The presence of Bacillus coli in a wound is not sufficient evidence of fecal fistula. In doubtful cases, the oral or rectal introduction of a dye, such as methylene blue, with its subsequent appearance in the discharge from the wound confirmed the diagnosis. An opaque medium, as lipiodal, may be injected into the sinus, a roentgenogram taken, and the fistulous tract thus outlined.

L. H., with a cervico-sigmoid fistula, complained of passing gas through the vagina. The diagnosis was confirmed by a roentgenogram following the injection of lipiodal into the cervical canal.

Internal fistulas, or fistulas between intestines or pelvic viscera and intestines, have been included, though these had formed spontaneously and were not incurred at operation. They were treated and repaired in the same manner as were the injuries opening into the bowel lumen. There were three such cases, as follows:

1. I. S. Sedimentation rate upon admission was 18 mm. in twelve minutes and 18 mm. in eighteen minutes before operation seven weeks later, though temperature was normal, indicating continued acute inflammation. At operation a large infected ovarian cyst was found, to which the small intestine, sigmoid and omentum were densely adherent. During separation there was escape of pus from the cyst into the peritoneal cavity. The abscess in the wall of the sigmoid which communicated with the infected ovarian cyst was incised and drained and the wound was closed by three layers of interrupted fine chromic catgut sutures. The ovarian cyst was then removed. Eight cigarette drains were inserted, two in each lumbar gutter and four to the cul-de-sac. Infection of the lower half of the wound developed, but this healed and the patient was discharged thirty-four days postoperatively with a small sinus in the lower right angle of the wound. She did not develop a fecal fistula.

2. L. B. The initial sedimentation rate was only 18 mm. in fifty minutes, indicating no acute infection. There were very dense adhesions between the uterus and dermoid cyst and small intestine. These were easily separated. There was a fistulous communication, ⅜ of an inch in diameter, between the dermoid cyst and the small intestine. The fistula in the intestine was closed with three layers of fine chromic catgut. Two cigarette drains were placed in the pelvis. Wound infection developed, but the patient was discharged twenty-five days postoperatively with a clean wound. A fecal fistula did not develop.

3. C. H. A right salpingo-oophorectomy and a left salpingectomy and an appendectomy were done for bilateral pyosalpinx and an old appendiceal abscess which was found eroding the ileum. Sedimentation rate was rapid, 22 mm. in fifteen minutes, upon admission. The patient was in the hospital thirty-five days before she was considered ready for surgery. There was a fistulous opening 1½ cm. in the terminal portion of the ileum communicating with the old appendiceal abscess. There were dense adhesions of the small intestines to the

uterus and the adnexae. The opening in the intestine was repaired by three layers of Pagenstecher. Three Penrose drains were placed in the abdomen. The patient was discharged twenty-five days postoperatively with a clean wound. A fecal fistula did not develop.

### TREATMENT

*Propbylaxis.* The sedimentation rate seems to be the most reliable test to determine subsidence of infection in pelvic inflammation. As has been pointed out, surgery should be delayed until the sedimentation rate is normal, if possible. Dissection of adhesions in those cases with a rapid sedimentation rate produces bleeding and injury to the bowel. Injury is much less likely to occur, and, if it does, the tissue is not as friable and can be more successfully repaired if there is little or no intestinal exudate. Traumatism in handling the intestines must be avoided with careful use of moist gauze pads and removal of the intestines from the field of operation.

Sharp dissection with scalpel or scissors should be done whenever possible instead of blunt dissection. Where it is difficult to separate dense adhesions between intestines and pelvic viscera, it is best to dissect off a thin shell of the uterine wall or of the ovary or tube and leave it attached to the intestine.[13] In all cases following a difficult dissection, especially where active bleeding occurs, a careful search should be made for possible intestinal injury before the abdomen is closed.

*Treatment of Fecal Fistulas.* The treatment of fecal fistulas low in the intestinal tract, as in the terminal ileum, sigmoid, or rectum, is much less urgent than those located in the duodenum or upper jejunum due to the slight loss of fluids, food and enzymes. Fistulas of the large bowel, or terminal ileum, usually heal spontaneously. Sufficient time should be allowed for the fistulas to close spontaneously before surgery is attempted. Nelson states that these fistulas should not be operated upon for at least a year, as in this period of time most of them close spontaneously. Treatment is directed toward keeping the wound clean, the skin edges protected and giving the patient adequate care. Dressings should be changed several times daily and the surrounding skin washed with alcohol and covered with zinc oxide ointment, aluminum paste, or a 5 per cent sulfathiazole in a heavy petrolatum base. For the first week following the discovery of a fistula, treatment should be limited to the above until local adhesions have walled off the fistulous tract from the general peritoneal cavity. Saline may be injected into the rectum and drained through the wound and daily irrigations of Dakin's solution may be used in the wound.[14] Warm tub baths daily, the patient remaining in the water for fifteen to thirty minutes, help keep the fistula and the skin of the abdomen clean. Excessive granulation tissue at the mouth of the fistula, or epitheliazation of the fistulous tract, may be destroyed with silver nitrate or actual cautery.

The principles of successful closure are thorough exposure of the opening in the bowel, separation from the abdominal wall, complete mobilization and the inversion of the edges of the fistula into the lumen of the bowel. An excision of the fistulous tract with a simple closure of the opening into the bowel may be done. If this is not possible, due to the extensive adhesions of loops of the intestine, a short-circuiting operation between the intestines above and below the fistulous opening may be tried. Most cases require a simple extraperitoneal suture of the intestine.

Two cases were discharged with persistent fecal fistulas; one, L. H., had a cervico-sigmoid fistula and the other, B. Mc., a fecal fistula following a fundectomy and sterilization for advanced pulmonary tuberculosis. She was three months gravid and though there were no intestinal adhesions, the patient developed a fecal fistula of undetermined origin twenty-four days postoperatively.

Three cases had a colostomy performed: E. H., after persistent fecal discharge through three sinus openings for six months postoperatively. The fecal fistulas did not close and the patient died four months later. M. S., forty-one, had a colostomy performed at the original operations as it was necessary to do a resection of the sigmoid which was buried in a solid mass of adhesions filling the pelvis. The friable sigmoid colon tore away and the proximal end was brought through the abdominal wall. The colostomy was closed sixteen months later. Fecal fistulas did not develop. M. S., forty-six, had a colostomy for intestinal obstruction which developed nine days postoperatively. The patient was discharged four months postoperatively and readmitted six months later for closure of colostomy and repair of fistula. Two openings were found in the sigmoid and two in the transverse colon. She was discharged five weeks later, cured.

There were five deaths in forty-two cases, two following a generalized peritonitis without fecal fistulas. Three patients died, apparently, of chronic sepsis associated with fecal fistulas. One, A. B., with operative diagnosis of fibroid and acute salpingitis, had considerable bleeding during dissection of adhesions between uterus, adnexa, bladder and sigmoid. She was discharged five weeks postoperatively, but readmitted ten weeks later with a diagnosis of abscess of the abdominal wall. This was drained and irrigated for two months before a diagnosis of fecal fistula was made. The patient died suddenly six days later. E. R. sustained a laceration of the intestinal serosa in separating adhesions from the adnexae, uterus and intestines. This was repaired and two abdominal drains were inserted. In this case, extensive dissection was necessary to isolate the pelvic viscera. The sedimentation rate was 18 mm. in thirteen minutes on admission and 18 mm. in thirty-four minutes preoperatively seven weeks later. A fecal fistula developed six days postoperatively. She was discharged with a small sinus in the lower angle of the wound, but was readmitted seven weeks later draining profusely. The wound was revised and a fecal fistula discovered. Despite active local and general treatment, the patient died one month later. Thus, of the eighteen cases of fecal fistulas, three died, one was surgically repaired, and two were discharged with persistent fistulas. The other twelve cases healed spontaneously.

## CONCLUSIONS

1. In a series of 5,055 laparotomies performed at Harlem Hospital on the Gynecological Service, there were forty-two cases of intestinal injury, of which eighteen developed fecal fistulas and two, general peritonitis.

2. The chief predisposing causes of intestinal injury are adhesions and friability of the intestinal wall in pelvic inflammatory disease.

3. The most reliable index of acuteness of pelvic inflammatory disease is the sedimentation rate. A slow sedimentation rate is the chief prophylactic measure against intestinal injury.

4. Where there is a possibility of intestinal injury, diligent examination of the intestines should be made, since recognition and immediate repair is essential.

5. The value of drainage is questionable.

6. In seventeen cases there must have been bowel injury which was not recognized at time of surgery.

7. Fistulas of the sigmoid, rectum, and ileum, the portions of the intestine generally involved in gynecological surgery, usually heal spontaneously within a year.

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RECTOVAGINAL fistula is by far the most common form of vaginal fecal fistula. The possible *causes* are in the main the same as those concerned in the etiology of urinary fistula. The operations which are most apt to be followed by the development of such a fistula are vaginal puncture for pelvic abscess, perineorrhaphy and hemorrhoidectomy.

From "Textbook of Gynecology" by Emil Novak—2nd ed. (Williams & Wilkins Company).

# PRIMARY TREATMENT OF WAR AMPUTATIONS

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THIS brief report is stimulated by caring for a group of thirty-seven major amputations arriving at a general hospital in the tropics during a recent campaign.

Certain features of primary treatment such as level of and method of amputation and the application of early adequate skin traction are discussed in the hope of improving final results by aiding those men doing primary amputations.

The term "guillotine amputation" has been used to describe the sound expedient method of amputation employed by forward installations of the U. S. Army to diminish the hazard of infection. It appears from this study that the term is misleading in that it implies division of all structures of the extremity at one level with no provision for subsequent closure of the stump. Four thigh amputations in the series had been carried out in a strictly guillotine manner at such a high level that the resulting stumps were poor and the bone length too short to allow re-amputation. It would hence seem advisable to discard the term "guillotine" and use in its place, simply the term "open amputation." The proper concave method of open amputation has been emphasized by Kirk.[1,2]

Thirty-seven major amputations were treated in thirty-five patients with no deaths in the series. Table I shows the agents responsible for the trauma which led to amputation. It is seen that the majority of the injuries were due to enemy missiles. Ten of these were due to mortar shells, six to rifle and machine gun fire and the balance to artillery, mines and grenades. One ankle injury from grenade fragments was amputated below the knee for gas gangrene two days later in an evacuation hospital. This patient received 80,000 Oxford units of penicillin intramuscularly and 1 Gm. of sulfathiazole every four hours for nine days. The patients injured by U. S. missiles resulted from premature explosions, defective shells, errors in range and mistaken identity in battle. The accidental cases were due to vehicles, dynamite and shell explosions.

TABLE I
CAUSATIVE AGENTS IN THIRTY-SEVEN MAJOR AMPUTATIONS

| Enemy Missiles | Enemy Missiles and Gas Gangrene | U. S. Missiles | Accidental | Self-inflicted Gunshot Wounds |
|---|---|---|---|---|
| 21 | 1 | 8 | 6 | 1 |

All the amputations were of the open type and were received with vaseline gauze dressings in place. The wounds, though showing a moderate amount of purulent drainage, all appeared healthy and responded rapidly to Dakinization and supporative systemic treatment of the patient. The patients arrived usually three to ten days after injury. All had markedly reduced hemaglobin estimations of 30 to 50 per cent. All had received tetanus toxoid, blood plasma and sulfathiazole Gm. 1 every four hours prior to arrival here. Half received whole blood transfusions at one or more stages of evacuation and approximately 40 per cent received penicillin 20,000 Oxford units prophylactically every four hours for several days following injury.

Table II shows the sites of amputation and the number in each group. It is seen that there were twice as many amputations of the lower extremity as of the upper and that thigh amputations predominated over all others. During this same period

there were fifteen additional patients with severe amputations of fingers and toes which are not included in this series with the major amputations.

Table II
SITES OF THIRTY-SEVEN AMPUTATIONS

| | Thigh | Lower Leg | Foot | Upper Arm | Fore-arm | Wrist |
|---|---|---|---|---|---|---|
| Upper.... | 5 | 3 | | 3 | 0 | |
| Middle... | 9 | 2 | 1 | 0 | 5 | 2 |
| Lower.... | 2 | 2 | | 0 | 3 | |
| Total.. | 16 | 7 | 1 | 3 | 8 | 2 |

Table III shows that only six patients in the series were admitted with adequate skin traction in place. The healing time was much shorter in these six cases, the treatment simpler and the quality of the resulting stumps better. All patients who did not have early skin traction required freeing of the skin at secondary operation, re-amputation or plastic procedures.

Table III
SKIN TRACTION ON ADMISSION

| | No. Cases | Per Cent |
|---|---|---|
| Adequate | 6 | 16 |
| Inadequate | 2 | 6 |
| None | 29 | 78 |
| Total | 37 | 100 |

Table IV shows that poor stumps were obtained or forming at the end of the study in eight cases. Seven were due to poor healing resulting from the presence of inadequate soft tissues. None of these seven had skin traction applied prior to admission. The eighth poor result occurred in a distal forearm stump which developed a sensative radial neuroma in spite of good soft tissue healing.

Table IV
RESULTS

| | No. Cases | Per Cent |
|---|---|---|
| Satisfactory | 29 | 78 |
| Poor | 8 | 22 |
| Total | 37 | 100 |

Three of the seven patients had inadequate soft tissues resulting from the severity of the original injury as shown by the field medical records. The remaining four cases were thigh amputations performed in a true guillotine manner at a high level. Though the difficulties of evaluating the true extent of the original injury is appreciated, it seemed that more bone and soft tissue might have been preserved in these cases if its great importance had been appreciated. Adequate skin traction immediately after amputation would have favorably influenced the outcome by preventing soft tissue retraction. It also appeared that the quality of these four stumps was greatly impaired by the division of all structures of the extremity at one level. The proper concave method of open amputation advised by Kirk and McKeever[2] or the short flap method recommended by Orr[3] would have been no more difficult to perform and given excellent soft tissue healing if skin traction had been applied early.

The removal of the whole or major portion of an extremity is crippling surgery and an attitude of conservatism should always prevail. In traumatic and infected cases this is especially true since careful conservative treatment will frequently lead to recovery with a useful extremity. In dealing with the upper extremity, the surgeon should always err in trying to preserve a hand or portion of it as long as possible. Even a thumb and one finger stump may prove to be very useful to the patient.

In war the main indications for amputation are severe explosive injuries which mangle the part, penetrating wounds which divide main arterial trunks as well as accidental crushing injuries. Less frequently severe spreading infection such as gas gangrene which threatens the life of the patient is an indication for amputation.

When a portion of an extremity is no longer viable as manifest by absence of pulse, coldness, color changes and loss of sensation, amputation must be resorted to as soon as the general condition of the patient permits. The open method used in time of war is an expedient to diminish the hazard of infection, allow free drainage and diminish the incidence of gas gangrene.

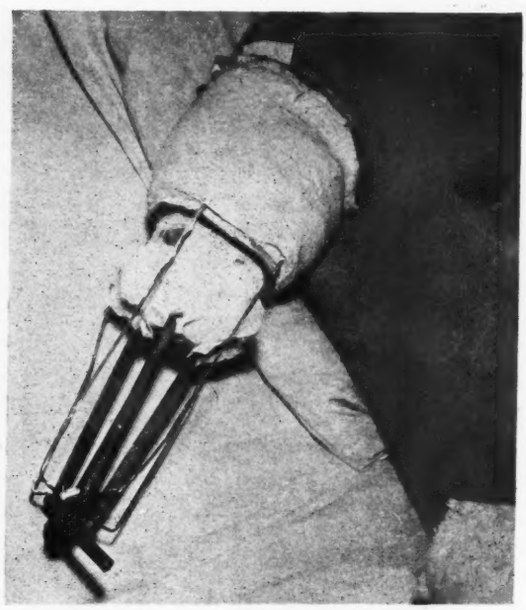

FIG. 1. Wire framework built with padded circular plaster about the arm. Traction produced by rubber tubing through the eyes of the adhesive strips and tied over the end of the frame. Works well for arm or leg.

In judging the site of amputation it is highly important to preserve all possible healthy tissue. The skin should be incised parallel with and 1 cm. proximal to the line of demarcation when a line is present. When the amputation is done prior to demarcation, the lowest level at which the tissues bleed freely should be chosen. The facia and successive layers of healthy muscle should each be divided more proximal than the previous layer down to the bone. It is better to lose a skin edge by cutting too close to the line of demarcation than to sacrifice useful skin covering. However, care must be taken to leave no non-viable deeper tissues. The distance which the bone should be divided higher than the skin incision should vary with the diameter of the extremity at the site of amputation. For example, the thigh requires approximately three inches of skin to cover the end of the stump while in the arm one and one-half to two inches is sufficient.

Since the primary procedure in an open amputation is not expected to be final, the safest principle is to preserve the greatest length of extremity possible, so that re-amputation can be carried out at the optimum site for prosthesis if necessary.

The method of open amputation advised by Kirk and McKeever[2] is outlined as follows:

1. The skin of the extremity is incised in a circular or oblique manner just proximal to the line of demarcation and allowed to retract.
2. The deep fascia is then incised at the level to which the skin has retracted.
3. The muscles are divided in a concave manner, each layer more proximal than the previous down to the periosteum.
4. Vessels are securely ligated.
5. Nerves are ligated, severed high and allowed to retract without injection.
6. The periosteum is sharply incised about the circumference of the bone.
7. The bone is sawed even with the periosteum leaving no ragged edges. The periosteum is not removed from the tip of the bone.

If all these principles are properly followed and skin traction started immediately after operation, results are excellent since adequate soft tissue is preserved to cover the bone end. Orr[3] favors the fashioning of flaps longer than the bone instead of a straight circumferential incision. The healing of the stumps in this series done by this technic was excellent due to the extra amount of soft tissue present. It is better to err in saving excess rather than insufficient healthy soft tissue providing the wound is kept open and is not permitted to close until all danger of infection has passed.

The value of early skin traction applied to an open amputation stump lies in its prevention of soft tissue retraction. It transforms even a slightly convex stump end to a concave surface with soft tissues drawn down beyond the bone. The size of the wound is diminished and healing time hence shortened. Furthermore the size of the scar at the end of the stump is much smaller, giving a better stump end when re-amputation is not necessary. By keeping the soft tissues drawn down into place, the necessity for re-amputation is diminished.

The effectiveness of skin traction diminishes the later it is applied, due to skin retraction and fixation to subcutaneous tissues. It is, therefore, important to apply traction as early as possible, preferably immediately after operation.

To hold the traction in place during evacuation, an appliance such as that shown in Figure 1 is easy to make and very effective. It is readily constructed with wire, felt and plaster as is self-explanatory in the picture. This type of plaster cuff is comfortable, protects the wound, allows dressings with ease and maintains constant adequate pull on the skin by means of rubber tubing. The tubing from a blood plasma set serves ideally for the purpose.

Since adhesive tape has a tendency to slip from the skin due to wound drainage and soiling during the early postoperative period, care must be taken in its application. As in applying Buck's traction strips, thorough cleansing of the skin with ether followed by an adhesive material such as compound tincture of benzoin is important. Four strips of adhesive are sufficient, the width varying with the size of the extremity so that the space between the strips is not over two inches. Two circular strips of the same width should be applied over the others followed by firm bandaging preferably with elastic bandage. This will give sufficient adherence to last six to eight days in spite of dampness, soiling and wound drainage. By this time the patient is usually in a fixed hospital where the adhesive can be changed. A spreader of wire or wood can be inserted later if desired but it is not essential. When the dressing is done, the rubber tubing is untied, and the adhesive strips laid back giving direct access to the wound. The adhesive strips hold the dressing in place when traction is applied making the change of dressings simpler. Stockinet applied with 'Ace Adherent' may be used instead of adhesive tape.

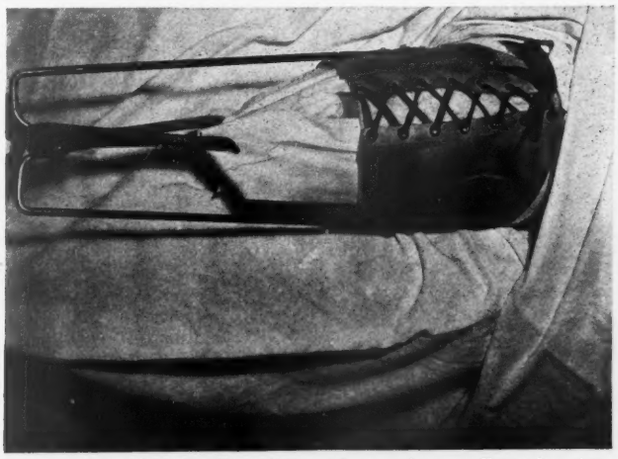

FIG. 2. A light, laced, adjustable leather cuff with wire framework useful in maintaining traction and in making the patient ambulatory.

Figure 2 shows an adjustable light leather cuff which has been made at this hospital and which works well. Being lighter it serves well in all stages of

healing and allows the patient to become ambulatory at an earlier time. This improves morale, encourages motion of joints with prevention of stiffness and contractures and diminishes the hazard of pulmonary complications.

SUMMARY

1. Thirty-seven major open amputations are discussed.

2. Use of the term "open amputation" in place of the term "guillotine amputation" is recommended.

3. Proper methods of open amputation and the value of skin traction are discussed.

4. Methods of maintaining adequate skin traction during transportation are discussed.

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One requisite of a good stump is that the severed muscles receive a new insertion at the stump end. Redundant muscle tissue is useless and makes the stump more difficult to fit and prone to chafe. It is very important that cut ends of muscles or their tendons be grouped about the end of the bone and fixed to the periosteum and fascia or to each other so that they will not retract and leave the bone exposed beneath the skin after healing.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# INTERNAL DERANGEMENTS OF THE KNEE*

## DIAGNOSIS AND TREATMENT

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INTERNAL derangements of the knee, particularly meniscus injuries, continue to be a timely subject in view of the frequency of this condition among our troops in training. They are, indeed, a most frequent cause of chronic disability of the knee joint, and, despite our highly developed surgical technic, the postoperative results seem too frequently disappointing. Soldiers often reject the suggestion of operation for such derangements because of knowledge of poor results with other patients. The poor results usually derive from incorrect diagnosis or incomplete or late surgery rather than mistaken judgment or the surgical method employed. It is often difficult to make an accurate diagnosis of the type of derangement, and, in all probability, the lesion most often overlooked is a torn posterior segment of the meniscus. In the light of a careful history, a meticulous examination and comparative *x*-rays of the injured and opposite knees, one may, in most cases, localize the lesion to the proper compartment of the joint and also differentiate cases in which the patients should be conservatively treated.

### MECHANISM OF INJURY

Careful history will indicate that all meniscus injuries result from a rotation-abduction or rotation-adduction strain of the flexed knee. There are apparently two frequent mechanisms whereby these injuries occur. In one, the meniscus is rammed against the femoral condyle by a force directed through the tibia. The usual examples of this mechanism are those of the runner who is tackled sidewards in football or the runner who, with weight fixed on one foot, pivots suddenly in the opposite direction. In both of these instances, the knee is flexed and the tibia rotated and abducted.

The other mechanism is an analogous force directed through the internally rotating femur. The final phase of normal extension of the knee is accompanied by internal rotation of the femur. The mobility of the menisci varies in individuals and this may explain the susceptibility to injury. Aside from the more marked mobility of the medial meniscus, the frequency of injury of this cartilage may depend upon another anatomic feature. The femoral condyles have a wheel-like action and are set posteriorly in relation to the long axis of the femur, the medial condyle or wheel being larger than the lateral. Although the condyles rotate synchronously in flexion and extension, the rotary arc of the medial is greater than that of the lateral. In the process of extension, when the lateral condyle has come to rest, the medial continues to rotate thus pivoting the femur internally. If, in this final phase of extension, the tibia is fixed in abduction and external rotation, the medial meniscus can be impinged and ground or split beneath the rotating medial condyle. This mechanism occurs in extending the knee rapidly in rising from a crouching position. In marked flexion of the knee, weight is borne far back on the head of the tibia, and a weight bearing rotation strain imposed in this crouching position is

* This paper was presented at the Tenth Fracture-Orthopedic Conference sponsored by the Air Surgeon at Jefferson Barracks, Missouri, November 19 and 20, 1943. Major Howard G. Weiler, M.C., Chanute Field, Illinois, collaborated in the statistical analysis of the cases reported.

probably responsible for posterior cartilage tears. The relaxed capsule and lateral ligaments escape tearing injuries in these mechanisms.

In this respect, Major Caldwell, writing in the *Military Surgeon*, June, 1943, has recorded certain observations which we have also noted. He reports a striking frequency of degenerative changes of the articular cartilage of the femoral condyles in cases of meniscus injuries. He has recorded his observations statistically, noting about 67 per cent of cases of medial meniscus injuries revealed degenerative changes of the medial condyle. There was a lesser incidence (about 26 per cent) of lateral condylar changes in lateral meniscus injuries. Such changes will not be particularly noted unless they are sought, and will range from only a mild but definite fibrillation to fragmentation or frank osteochondritis dissecans. We noted two cases of osteochondritis dissecans complicating medial meniscus injuries in our group of cases. Caldwell believes these degenerative changes to be due to trauma incident to the mechanical derangement, and in direct ratio to the duration of disability, and apparently not directly related to the severity of the initial trauma. Although not as frequently observed in recent injuries, they will be found in such cases also. It is important to regard the presence of such articular changes as sufficient reason for excision of a meniscus even though it appears normal. Caldwell further states that in every instance in which a normal appearing meniscus was removed, a posterior tear was found.

## ANALYSIS OF CASES

Without intending this to be a statistical report, we wish, nevertheless, to record certain data upon which our impressions and conclusions are based. In the course of one year from June 1, 1942 to June 30, 1943, several hundred knee cases were examined, over one hundred knee injuries treated conservatively, and sixty-two cases operated upon for meniscus injuries and two for cysts of the lateral meniscus. We are deleting from this discussion operations for other derangements, diagnosed as other than meniscus injuries. The age range of our patients was from nineteen to thirty-seven years with an average age of 25.7 years. The duration of symptoms extended from four days to thirteen years; and the average duration of disability prior to operation was 3.5 years.

Of these cases, there were forty-one with recurrent or chronic symptoms, and twenty-one with a recent single injury; twenty-five were athletic injuries in civilian life; six were due to industrial accidents in civilian life; three existed prior to induction, but were unrelated to any accident; twenty-eight were service connected injuries, and two were cysts of the lateral meniscus.

They were further analyzed as follows:

13—buckethandle tears
29—transverse tears
  18—were anterior
  2—middle
  9—posterior
12—marginal detachments
  6—anterior
  1—middle
  5—posterior
2—longitudinal tears
2—hypermobile cartilages
2—cases of anterior medial cartilage tears in conjunction with frank osteochondritis dissecans

In addition, there was one patient operated upon for removal of a large loose body in the posterior compartment of the right knee, who had undergone an operation two years previously for removal of a torn medial meniscus. At operation a well formed fibrocartilaginous rim was found to have regenerated in place of the absent meniscus. The regenerated fibrous band measured about 10 mm. in diameter and was firmly adherent to the capsule. It is to be noted that posterior meniscus tears in

the series totaled fourteen, a frequency equivalent to the buckethandle type. Among the complications encountered in this entire group, in conjunction with meniscus injuries, were five cases which revealed anterior cruciate ligament tears, two cases which presented fractures of the anterior tibial spine, and three cases with marked chondromalacia of the patella.

In one case of hypermobile cartilage the only gross disorder to account for locking was a tear of the anterior cruciate ligament. Following removal of the cartilage, the free torn ligament was excised. No repair was done.

Two of the cases presented tears of the lateral meniscus, in addition to severe injury of the medial meniscus, and in each case both cartilages were removed.

One case was a complicated injury in which an extensive tear of the anterior capsule of the joint and the patella ligament laid open the meniscus attachments to the capsule.

Two patients with lateral discoid meniscus gave histories of injury, but in each case diagnosis was established prior to operation by characteristic history and findings.

One patient operated upon for rupture of a medial meniscus of the right knee, and fully recovered, was readmitted five months later with a history of reinjury to the knee. All signs indicated a rupture of the lateral meniscus. Upon failure of the joint to recover by conservative methods, an arthrotomy was performed three weeks after admission, and the lateral meniscus was found completely torn from the posterior and middle capsular attachment. The cartilage was literally coiled in a tight ball in the anterior lateral compartment, and it was removed by simply severing the anterior attachment. Recovery was uneventful and the soldier returned to duty in twenty-nine days.

Hypertrophy of the infrapatellar fat pad was found present in all but eleven cases of long standing disability, and subtotal excision was done in these instances.

Partial excision of the injured meniscus was done in only three cases, early in the series, of the buckethandle type.

An average of eight days was devoted to preoperative hospital care. In the group of twenty-one recent single injuries operation was done within four days to four weeks of the trauma.

The average postoperative hospital stay was thirty-one days. The shortest stay was fourteen days and the longest stay was 107 days. In this latter case the patient developed a postoperative joint hematoma, and required subsequent knee manipulations for restoration of mobility.

All patients operated upon were returned to duty with the exception of one with a service connected injury, and in whom the meniscus tear was complicated by a tear of the anterior cruciate ligament. After a period of eight months of postoperative observation, this soldier was discharged from the service.

There were no postoperative joint infections. Healing was primary in all but three patients who developed postoperative hematomas; one patient developed a synovial sinus which persisted for fifty-six days; drainage was repeatedly sterile to culture. Two patients developed streptococcus sore throat during the early period of postoperative convalescence, but the wounds healed by primary intention. No sulfa drugs were implanted in the joints or wounds, but forty-three of the patients were given sulfathiazole orally for three to five days postoperatively. The daily dose was 4 Gm. per day. One of the nineteen untreated patients healed by secondary intention following release of a joint hematoma.

Eleven patients required joint aspirations during the early postoperative period for intra-articular hematomas.

Two patients required postoperative knee manipulations for restoration of motion (one with chondromalacia of the patella, one with chronic synovial changes).

Quadriceps recovery was satisfactory in all patients but one, who developed a postoperative hematoma.

At the time of discharge from the hospital, joint motions were, as a rule, restored to complete extension and 75 degree flexion, or better. Only five cases lacked 5 degrees to complete extension, and only six lacked active flexion to beyond 90 degrees.

We do not believe it wise to shorten the hospitalization required before a return to duty status. A minimum of four weeks is needed in most cases for adequate restoration of weight-bearing function.

## DIAGNOSIS AND CRITERIA FOR OPERATION

There are three general groups of patients with findings indicative of meniscus injuries:

1. Those with a typical history of recent injury and presenting characteristic findings. These are: True locking, in which the joint is locked in semi-flexion, and extension is definitely limited by a rubbery resistance. There is pain and tenderness referred to the site of the torn cartilage. Locking is an especially reliable sign when it is accompanied by a catching sound on forced extension of the joint. Occasionally, it is possible to feel a meniscus slipping in and out of position.

2. Another group of patients presents a history of recurrent episodes of locking with minimal objective findings. These are the so-called latent displacements. Aside from recurrent locking these patients may have other predominant symptoms: a sense of weakness and instability of the joint or periodic synovitis.

3. A third group of patients with a history suggestive of meniscus injury presents persistent symptoms of pain, rather generalized tenderness, and definite limitations of motion; stiffness is the predominant symptom.

The sign of locking itself is not a criterion for diagnosis of a meniscus injury or for operation. Conditions which may simulate locking are tears of the anterior cruciate ligament, hamstring spasm secondary to minor trauma, flexion of the joint to accommodate increased synovial fluid, thickened synovial folds and hypertrophied fat pad, radiolucent osteochondroma, osteochondritis dissecans, and chondromalacia of the patella.

In the twenty-one fresh injuries of this series locking was a definite symptom and sign in each case; it was also the predominant symptom in forty-three patients of the entire series.

Uncertainty as to the nature of the locking in a recent injury may often be clarified, after aspiration of the joint and a period of bed rest with knee traction. Patients with suspected cartilage injuries should be sent to the hospital at once. We have seen instances in which the torn fragment was displaced into the intercondylar area, and in which apparent complete extension of the injured knee was obtained by manipulation or traction. In such cases, however, careful observation will usually reveal a lack of normal joint hyperextension when compared with its fellow.

In recent injuries, following manipulation or a period of traction at bed rest, when active joint motions have increased, and swelling has subsided, if the cartilage remains displaced a spring-like resistance to extension will persist. When the lesion is an anterior or posterior horn tear, and does not produce persistent locking, a definite diagnosis becomes more difficult. In all recent cases, however, localized tenderness is a constant significant sign and is present in every case of meniscus injury. Tenderness may not indicate the nature or the extent of the tear but will localize the lesion to the proper compartment.

The McMurray or "click test" as described by Watson-Jones is undoubtedly a valuable aid in diagnosing a posterior horn lesion in late cases, but it is our impression that the test is less helpful in recent injuries.

The test is done with the patient supine and the knee fully flexed; the tibia is forcefully rotated inward and outward and also moved sideward in abduction and adduction. The palpating hand on the joint line will note any loose posterior fragment slipping between the femoral condyle and tibial tuberosity, and the resulting click can be localized to either posterior compartment of the joint. If this maneuver does not disclose a typical click, the tibia is then rotated and abducted or adducted in the flexed position, and then slowly extended. A palpable and audible click can then be elicited as the displaced fragment slips between condyle and tuberosity. Captains Slocum and Moore, reporting on the value of this sign, in a recent paper, have recorded the sign as positive in every instance of a posterior meniscus tear in their experience. Posterior meniscus tears, however, are found in cases in which the sign is absent, and it has been noted as positive in buckethandle tears.

In evaluating this sign, it must be remembered that posterior tears exist frequently in conjunction with other cartilage injuries and may occur as second or subsequent injuries. The determination of an injury to the posterior horn is important if one employs a routine surgical approach. The only certainty of dealing properly with a posterior tear is a complete removal of the meniscus; this calls for an adequate approach which does not appear possible by a single anterior incision. We have adopted the practice of resecting the entire meniscus through two incisions in all cases. Only three patients in our series had a partial excision of a torn cartilage, and these were buckethandle tears in early cases.

In the early months of our service we adopted a conservative attitude in dealing with fresh meniscus injuries. This was done in an effort to clarify the diagnosis in many cases, and also to differentiate a peripheral detachment from a substance rupture of the meniscus.

These patients with initial injuries were treated by bed rest with traction, aspiration was done early, and repeated if required, and in many instances manipulations were done prior to application of traction. Following a period of seven to fourteen days in traction, when reduction of a displacement was apparently obtained, the joint was immobilized in a plaster-of-Paris bandage maintaining extension. These patients were returned to duty (usually school) in such support, which was maintained for three to four weeks. During this period of immobilization, they were instructed in quadriceps setting exercises, and, as a rule, following the second week, the support would be bivalved to permit re-examination, local radiant heat therapy and limited active exercises.

Although a statistical follow-up of these patients treated conservatively was interrupted by transfer of personnel, we had sufficient experience upon which to base conclusions. Both from our own experiences with these patients, and our observations of patients conservatively treated elsewhere, we have definitely ruled out such treatment. Non-operative treatment is uncertain, time consuming and invites prolonged incapacity. If the diagnosis is conclusive of a meniscus injury, early excision is the treatment of choice. The time required for conservative treatment is no less than that required for operative treatment. It is reasonable to suppose that many of our patients treated conservatively required operation later at other stations. Although there were as many marginal detachments as buckethandle and posterior tears in our group, the uncertainty of obtaining a reattachment should also exclude conservative treatment.

Even in fresh cases, with characteristic findings, difficulties occasionally arise in evaluating a history. One patient did not recall any injury to the joint but presented typical findings suggestive of a medial meniscus tear. Despite his assertion,

the cartilage was found torn along two-thirds of its length to the tibial attachment and displaced inward. Two patients, with typical findings, claimed the initial symptoms developed during sleep. In dealing with some patients these stories may be viewed with doubt, but cartilage dislocations have been known to occur during sleep. These may have been old injuries with redisplacements.

Another group of patients are those with recurrent symptoms. These patients describe attacks suggestive of redislocations of an injured meniscus. As a rule they present minimal objective findings, but complain of sudden episodes of pain and locking, occurring especially during exercises, or following particular activities. These symptoms may persist for a variable length of time, being of momentary duration, or last up to two weeks. Synovitis may develop with these attacks. During the periods between these attacks, they are comparatively or completely symptom free. If examined at such times, they are apt to be regarded as malingerers. In these cases, conservative treatment will certainly be of no avail. The practice of prescribing knee cages or elastic dressings is to be disparaged. Repeated displacements of a meniscus invite osteoarthritic and synovial changes, and these are often responsible for persistent symptoms after late surgery.

Locking is often not the outstanding symptom. Usually a sense of instability or weakness in the affected knee is the predominant complaint, and is noted particularly in climbing or descending stairs. In this group, the knee has a tendency to give way suddenly when under load in the semi-flexed position, but without actual locking.

Major Stamm, in discussing injuries of the knee joint, at a recent meeting of the British Orthopedic Association, related that in spite of the symptoms, no lesion of the cartilage could generally be found at operation in such cases. He conceded that operation may be justified when repeated attacks of locking cause severe disablement, but as a general rule it should be avoided for the results are not good. Our experience has been otherwise with patients of this sort, and it may be that total excision of the meniscus may account for a better prognosis.

Total excision of the meniscus is especially indicated in these cases, since repeated episodes do not imply displacement of the same segment. There may be multiple tears. One of our patients, operated upon twice in civilian life for a lateral meniscus injury, complained of persistent pain, instability and a sense of blocking on the lateral aspect of the operated knee. Upon reoperation, at Chanute Field, a large torn posterior segment of the lateral meniscus was removed together with a regenerated anterior portion.

Some of these patients do return with postoperative complaints, but these are usually of a minor nature and may be referred to postoperative knee strain, altered joint mechanics, or quadriceps weakness. The patients who have persistent postoperative complaints are likely to have other pathological conditions in conjunction with meniscus injuries. In the main, they admit marked benefit by operation. To my knowledge, only three patients in the group with persistent preoperative symptoms required reclassification to a Limited Service status. These three patients had persistent symptoms of joint stiffness, pain, and a sense of instability; the objective findings, however, indicated satisfactory postoperative results: motions were of normal range in complete extension, the ligament structures were intact and radiographic studies were negative. Patients with latent meniscus lesions may be regarded as "service aggravated" when the history indicates a fresh injury superimposed in the course of physical training.

The presence of a latent lesion must, of course, be suspected in all cases of recurrent locking, instability, and synovitis of the knee. In determining upon opera-

tion for such soldiers, judgment is influenced by the necessity of returning the patient to a full duty status. Since the diagnosis in these latent cases is made chiefly on the basis of the history, one must be mindful of the conditions which simulate locking; these have already been enumerated.

Patients showing definite arthritic changes in the joints, as evidenced by *x*-ray study, or clinically, by synovial thickening and restrictions of motions, were not operated upon, since it was believed that this group would not respond sufficiently to be of further use in the service. As a rule, such patients were discharged from the service or retained on Limited Service. But the view that such cases should not be operated upon under other circumstances (non-military) is unreasonable. Following removal of the injured meniscus, thickened fat pads and synovial folds, subsequent muscle training will frequently restore such joints to pain free function. Furthermore, a source of repeated trauma is removed. The difficulty in dealing with this group lies in the differential diagnosis of symptoms as due to meniscus injury or arthritic changes.

## OPERATIVE TREATMENT

All cases were done under tourniquet control. We have adopted a method of two incisions; one cannot rule out posterior tears through an anterior incision, and we do not believe adequate resection of a complete meniscus is possible through any single anterior incision, except in rare cases of peripheral detachment of the posterior horn or in markedly relaxed joints. Once a joint has been opened for a meniscus injury the entire cartilage should be removed whether the injury can or cannot be seen.

An anterior three inch parapatellar incision is first made, with the knee in extension, allowing an approach to the anterior compartments and an inspection of the condyles, intercondylar area, the quadriceps pouch, and patella. This incision may be converted into the utility type if necessary.

Depending upon the meniscus to be removed, a posteromedial or lateral incision three inches long is then made, behind and parallel to the lateral ligament, permitting access to the posterior compartment. The knee is then flexed to 90 degrees by lowering the leg end of the table. The cartilage to be removed is then freed at the anterior attachment and along the anterolateral attachments to the capsule. The liberated segment, well gripped, may then be displaced through the posterior incision, and a complete dissection of the posterior attachment is visually possible. In resecting the posterior horn of a lateral cartilage, it is important to avoid damage to the popliteus tendon, for a loosened segment of this tendon might cause locking postoperatively. Adequate surgery requires that the entire cartilage be removed, the thickened fat pads and synovial folds be resected, and any areas of chondromalacia be dealt with by removal of the affected cartilage down to healthy bone. For closure of the wounds the knee is again extended, and this practically approximates the layer edges of the posterior wound.

Considerable effusion must be expected postoperatively. Over a knee dressing and several layers of sheet wadding, extending from upper thigh to above the ankle, a compression flannel or muslin dressing is applied. Finally a posterior plaster-of-Paris splint is incorporated in the muslin dressing to maintain knee extension. The limb is elevated for forty-eight hours following operation, with ice bags about the knee.

Quadriceps muscle exercises are begun on the third postoperative day; patients may be taught the setting exercises in the preoperative period. These exercises are then continued at hourly intervals during the day for five to ten minutes. On the tenth day, dressings and splint are discarded, sutures removed, and active joint

motion initiated. Weight bearing is permitted after the tenth day. The usual patient required four weeks of hospital care, and thereafter most of these patients were granted a convalescent furlough of four weeks, or were returned to a light duty assignment for an equal period. Our observations indicate that these patients usually cannot return to the strenuous physical activity required in military training for a period of about two months postoperatively.

## CONCLUSIONS

1. In both initial and late cases of meniscus injury, surgery is indicated as soon as diagnosis is determined.

2. Cases with osteoarthritic changes, as evidenced by persistent symptoms and disability, are not suitable subjects for operation in military service.

3. Complete excision of the meniscus should be done in all cases. The method advocated for this purpose requires two incisions for a visual approach to both joint compartments.

4. Prognosis is generally good. Persistent symptoms postoperatively, which cannot be attributed to altered joint mechanics, knee strain or quadriceps weakness, are usually due to other coexisting pathological conditions, such as early arthritic changes (rheumatoid or osteoarthritic), chronic synovitis or chondritis.

5. Postoperative care includes early quadriceps exercises (after the third day), weight bearing and active exercises after the tenth day, and restriction of strenuous joint activity for about two months postoperatively.

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# ROENTGENOLOGIC EXPLORATION OF SINUS AND FISTULOUS TRACTS

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THE development or persistence of a sinus or fistulous tract is a disconcerting surgical phenomenon. Because the tract may extend through infected adherent tissues and into hollow viscera, and often in many unknown directions, blind surgical exploration is inadvisable. When necessary, surgery is best done after the entire extent of the tract is outlined roentgenographically and its form and directions determined.

Sinus tracts and fistulas are indistinguishable from their surrounding soft tissues since they are of the same density. While these tracts may contain air, the amount is usually insufficient to cast a definitely recognizable shadow. In order to demonstrate the adventitious paths injection of an opaque substance such as lipiodol is necessary. Any other opaque, non-irritating, freely flowing liquid may be used for this purpose.

In civilian practice this method of investigation has been used frequently in cases of biliary fistulas. In this hospital most of the tracts injected were secondary to gunshot wounds. Multiple lacerations of the bowel, secondarily infected fractures, or those in which sequestra had formed, were frequent sources of sinus tracts.

The injection should always be made under flouroscopic control, since the form, direction, depth and capacity of the tracts are usually unknown. It is almost impossible to predict the site of origin of a sinus, or to indicate which of many metallic fragments is the offending irritating locus. The external opening is indicated by attaching an opaque marker to the skin with adhesive tape. Depending upon the size of the opening, a catheter, cannula, blunt needle or even the nozzle of the glass syringe may be inserted into the sinus opening. If the injection is made slowly and without undue pressure, leakage is often avoided. Spot films may be made at intervals during the injection. Usually however, the films made in various projections with the over-the-table tube and the grid diaphragm will show everything necessary for the proper interpretation of the case. Care is taken to wipe off any spill-over of the opaque fluid onto the skin before taking the films in order to avoid confusing shadows.

This procedure may be done with safety as soon as the general condition of the patient permits manipulation. Gross infection is no contraindication since injection to the point of overdistention is never performed. In small closed tracts the injection is stopped when the patient complains of pain. Usually the tract will decompress itself by expelling the oil along the catheter before pain is experienced. Another film of the area is often made from twelve to twenty-four hours later. During this time, seepage may outline other pockets or connections with viscera which were not shown during the original examination. It may also be desirable to show how effectively a cavity drains itself.

Almost all sinuses which persisted in draining or which recurred after closure were examined.

The following examples are cited to indicate the complexity of the cases and the valuable information obtained with this procedure:

## CASE REPORTS

CASE 1. This patient was admitted with the residuals of a penetrating abdominal

wound in which the wound of entrance was in the midline in the sacrococcygeal region and the exit in the left upper quadrant. He had entered the knee joint. A pyoarthrosis developed with resulting ankylosis. A draining sinus persisted at the site of the original bullet

FIG. 1. CASE I. A small sinus tract resembling a pilonidal sinus situated at the level of the sacrococcygeal junction was injected with lipiodol. The oil entered a small pocket and thence the left ureter. A few globules entered the lowermost calyx. The patient had had dysuria, but no leakage of urine from the sinus opening.

incurred multiple injuries of the bowel and bladder.

On admission he complained of pain in the coccygeal area and severe dysuria and tenesmus. A double-barrel colostomy was present in the left side of the abdomen. A small sinus was present in the coccygeal region, simulating a pilonidal sinus. His urine was cloudy with numerous white cells.

The sinus tract was injected with lipiodol, demonstrating a connection with the lowermost portion of the left ureter.

CASE II. A bullet produced an oblique fracture of the distal end of the femur which wound. An examination of the knee showed the ankylosis, but failed to demonstrate any reason for the persistence of the drainage. Injection of lipiodol showed the tract to enter a small cavity in the knee joint. Curettage of the sinus tract and the small cavity resulted in healing.

CASE III. In the course of septicemia, this patient developed multiple abdominal abscesses. One of these located in the pelvis was drained, but soon after began to discharge fecal material. Because this persisted, the tract was injected with lipiodol. An irregular branching sinus was outlined which appeared to enter the large bowel. A small amount of barium

suspension injected per rectum was seen to meet the iodized oil in the sigmoid. Methylene blue injected into the tract was recovered in the feces. This sinus tract could not be demonstrated at autopsy two months later.

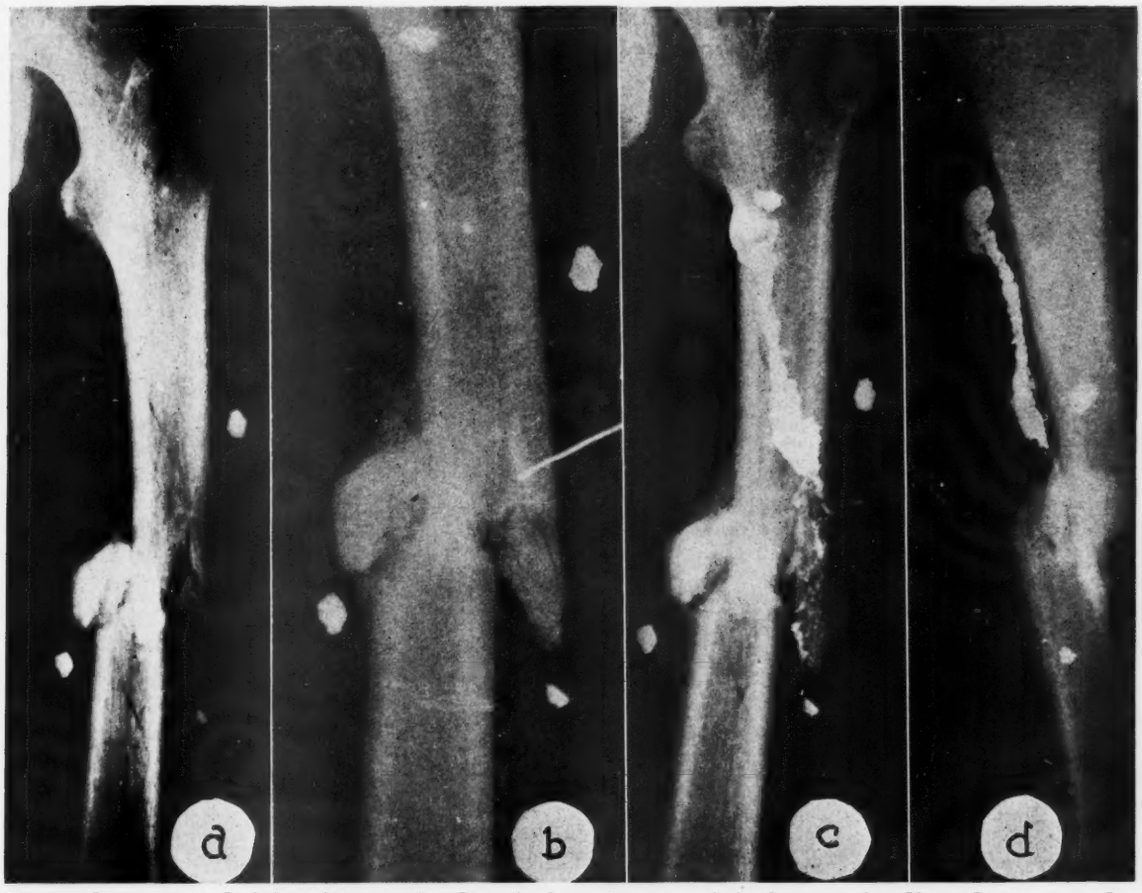


Fig. 2. Case vii. A draining sinus persisted at the lateral aspect of the fracture site. Since there was no demonstrable osteomyelitis one of the metal fragments was suspected of being the cause. (a), a probe inserted down to the bone did not approach any of the fragments; (b) spot film. As a last resort lipiodol was injected; the oil flowed to the metal fragment least suspected (c and d).

Case iv. Multiple high explosive wounds about the lower abdomen resulted in deposition of many large metal fragments and a draining sinus in the right buttock and another in the right pararectal region. The problem was to demonstrate both tracts and to determine, if possible, communications of the sinuses with the bowel or with each other. The gluteal sinus ended blindly at a large metal fragment. The pararectal sinus entered the rectum; the two sinus tracts did not communicate with each other.

Case v. A burst of machine gun bullets traversed the body of this patient from right to left at the level of the iliac crests, smashing the bodies of lumbar 3 and lumbar 4 and fracturing the crest of the left ilium, with separation of a small fragment of bone. A diplegia resulted. A sinus tract which drained persistently from the left side was thought to be due to the loose fragment of the crest of the ilium.

A catheter inserted into the sinus reached the fractured vertebrae. The lipiodol passed through a tunnel in the vertebral column to reach a large pocket on the right side of the abdomen. This communicated with the ascending colon on its posterior aspect about 3 inches above the ileocecal junction.

Case vi. A colectomy was performed on this patient for colonic polyposis with malignant degeneration. He became infected, very toxic and drained profusely from an opening near a right lower quadrant ileostomy, which was thought to communicate with the small bowel. Injection with lipiodol revealed the sinus to extend into a large abscess cavity which coursed along the left paravertebral gutter.

There was no communication with the small bowel.

Case VII. This patient sustained a compound fracture of his femur when an anti-aircraft shell exploded in his cockpit. Many small metal fragments became imbedded in his thigh. (Fig. 2A.) Drainage persisted from a large laceration over the fracture site. There was no roentgenographic evidence of osteomyelitis. A metal probe inserted down to the bone failed to approach any of the metal fragments. (Fig. 2B.) Lipiodol injection showed the surprising extent of the tract; it ran to the fragment farthest removed. (Fig. 2C and D.) The offending fragment was removed and the sinus tract healed.

## COMMENT

Draining sinuses are too often treated by non-interference, when a detailed investigation might easily lead to the discovery of a remediable lesion and hence to cessation of drainage and the closure of the sinus.

By the time the patients reach this General Hospital most of the metallic foreign bodies which are present in the gunshot cases are of importance only in their significant relationship to a continued draining sinus. None of our patients has suffered any ill effect from such an examination. Even the slight inconvenience caused the severely ill patients is of little consequence when the eradication of the source of prolonged debilitating drainage is the result.

## CONCLUSIONS

1. As has been demonstrated, the site of origin of the sinus tract cannot be determined roentgenologically without the aid of an opaque medium.

2. The site of the opening gives no indication of the location of the major portion of the adventitious cavity nor of the direction or number of its tracts.

3. The ease with which the examination can be done, the valuable information which may be obtained, and the almost complete absence of contraindication serve to indicate that every wound in which healing is not soon established, or which drains persistently, should have the benefit of this method of investigation.

# REFRIGERATION ANESTHESIA*

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THE use of cold as a therapeutic agent is as old as medicine. Ice applications and cold compresses for the relief of pain and for the reduction of inflammation have been used for many centuries. Within recent years, however, newer concepts of refrigeration have been developed. The familiar work of Fay[12] and his associates, in reducing temperatures over long periods of time in patients suffering from cancer, emphasized that a lower metabolic state, comparable to hibernation in lower animals, is possible in human beings. Whatever the value of these studies so far as any positive attack on the broad field of malignancy is concerned, they pointedly demonstrate that tissue metabolism can be slowed to a degree hitherto not thought possible. A more recent development, and the one that this paper is particularly concerned in describing, has been prompted by the observations of Allen[1,2,8,10] on the use of refrigeration in diabetic or arteriosclerotic gangrene or both.

For some time it has been known that tissues can be kept alive for many days at icebox temperature provided they are not frozen. In experiments, Allen[13] has demonstrated that the cooling of limbs or other parts with ice water or ice, cracked or pulverized, down to near the freezing point, say five degrees Centigrade (40°F.), is harmless. There is a temporary suspension of life, with resumption of cellular activity as the temperature returns to normal. In refrigeration of limbs for anesthetic purposes, complete stoppage of circulation is effected by careful application of the tourniquet. This, in brief, is refrigeration anesthesia, which becomes complete after one to two hours. Needless to say, freezing must be avoided.

## EXPERIMENTAL EVIDENCE

It has been shown by Fay[12] and his workers that irritation, heat and pain produce hyperemia in the segmental area of stimulation, conversely, cold produces vasoconstriction and hyperemia in the same neurological reflex arc. He showed that cold reduces the pain that is due to malignancy.

There is ample evidence that when the extremities of animals become totally ischemic as the result of deprivation of blood supply by a tourniquet, exposure to room temperature or to an increased temperature results in rapidly progressive tissue necrosis. It has further been observed that the reduction of temperature enables limbs to survive for a much longer period of time. Brooks and Duncan,[14] for example, noted that a rat's tail became gangrenous within four hours after ligation at a temperature of 40°C. When, however, the temperature was reduced to approximately 5°C., the survival period was extended to as long as four days. Allen[20] observed that the hind legs of rabbits, cats and dogs survive asphyxia for thirteen or fifteen hours at room temperature. When the temperature is reduced and maintained at approximately 2 to 4°C. the dangers of ligation are greatly diminished. Under these conditions, limbs showed a survival period of fifty hours or longer. Furthermore, the phenomena of shock, thrombosis, infection and injury to blood vessels and nerves were markedly inhibited.

## PHYSIOLOGY AND PATHOLOGY

The lowering of temperature to a level slightly above freezing produced anesthesia by stopping cellular metabolic

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processes. It puts the cells at absolute rest in a manner comparable to hibernation. Inactive cells will not respond to stimuli. It is a matter of elementary knowledge that plants and protozoa without nervous systems exhibit chemical protoplasmic reactions to injury. Equally familiar is the fact that operations under any known anesthetic are productive of shock in proportion to the duration and degree of tissue trauma. Mitigation of this recognized harm has been sought only through speed and delicate precision of the skilled operator. Crile had a true vision in his anoci-association, but refrigeration alone inhibits all protoplasmic activity, including the shock response.

Life processes, in common with chemical reactions, have a speed which is profoundly influenced by temperature. Oxygen consumption of the tissues can be reduced about 13 per cent for each degree Centigrade that the tissue temperature is reduced. When a tourniquet is applied and the extremity is packed in ordinary chipped ice (without salt) the oxygen demands are reduced sufficiently to prevent necrosis for many hours. The skin temperature falls to between 2 and 4°C. and surgical anesthesia is complete in about two hours.

It has been definitely shown that heat accelerates necrosis, whereas cold markedly prolongs the survival time of anemic tissues. Allen made the first clinical application of these laboratory observations in cases of arteriosclerotic gangrene of the leg. Subsequently, the value of refrigeration in arteriosclerotic gangrene and in limb sepsis and trauma has been repeatedly confirmed by observers who have made the clinical trial. In all these cases there has been a deficient circulation in the limb. Very few observers have claimed merit for refrigeration when normal circulation is present. The tissues are able to handle traumatic or septic conditions better with the aid of their normal physiologic inflammatory reaction than by suppression of this reaction by refrigeration. There is increased exudate, increased absorption and increased local heating of tissues with accelerated tissue metabolism which is beneficial as a normal inflammatory reaction. There is also a greatly increased tissue demand for oxygen at the same time which is out of proportion to the increased local blood flow. In a limb with deficient circulation, a disparity may exist between the supply and the demand for oxygen on the part of the tissue cells. As a result of this, the necrosis of tissue may occur if the inflammatory response is augmented by heat. The application of cold to such tissues is beneficial because it retards the oxygen demand of the tissues to a level commensurate with the available oxygen that is brought to the limb by the deficient circulation.

## ADVANTAGES

The principal benefit resulting from refrigeration is the lowered metabolism of the tissues and the resulting lessening of the oxygen demand. There is also efficient anesthesia secured by the action of refrigeration of nerve trunks and also by what Allen terms as "anesthesia of protoplasm." Nerve impulses are abolished. Also, one of the fundamental properties of protoplasm is irritability, but this and all other living activities are arrested by cold.

*Relief of Pain.* The immediate salutary effect of chilling of tissues on the more prominent signs and symptoms was most striking. Relief of pain was observed in every case and without the aid of the customary medication. It is well known that cases of sudden arterial occlusions, as from embolism, are most painful and that great discomfort persists for many hours after the initial obstruction. It was in this group that the relief of pain is most dramatic.

*Shock.* Shock has always been an outstanding and disturbing feature of thigh amputation, both during and after operation. In addition to operative trauma,

general and spinal anesthesia, particularly the latter with its frequent attendant fall in blood pressure, contribute greatly to secondary surgical shock. This phenomenon is not observed with refrigeration anesthesia. There is little if any pulse or blood pressure change. Shock is non existent except for the (usually slight) degree of it which may develop from the tissue injury remaining after the wound is finally closed and the temperature is raised to allow the protoplasm to resume its functions. This explains why a reasonably strong patient, after a thigh amputation by this method, can immediately return to the ward and eat a full meal as though nothing had happened, and, in general, why this anesthesia offers a radically new approach to the idea of accomplishing an operation while maintaining a constitutional condition as if there had been no operation. Since shock is non-existent, the duration and degree of tissue trauma are immaterial, and the essential factor is the state of the wound when normal temperature and blood flow are restored. Anesthesia of protoplasm, in contrast to nerve anesthesia, is said to be a factor in preventing shock; shock is also lessened by the diminished tissue necrosis, diminished bacterial growth and the diminished absorption from the local site because of the vasoconstriction brought about by refrigeration.

*Infection and Edema.* There is marked inhibition of infection and edema. This is in line with the familiar preservation of tissues in an icebox for days or weeks. Tissue devitalization, infection and shock are inhibited in proportion to the degree of reduction of temperature.[13] The progress of gangrene and sepsis is markedly inhibited by the application of cold. In these cases a tourniquet and refrigeration can be applied for as long as twelve hours or longer without progress of infection or gangrene and with first intention healing following amputation. However, reduction in temperature does not avert amputation when devitalization of a part has once occurred. It has been interesting to observe that when gangrenous limbs are exposed to ordinary room temperatures after refrigeration, gangrene progresses rapidly. A return to decreased temperature slows the process. The preservation of tissue vitality, the bacteriostatic action of cold and perhaps the high oxygenation of the blood and tissue fluids may explain the noticeably high resistance to infection in these cases. It has been shown many times with refrigeration anesthesia, that amputations at mid-thigh levels or higher, with the cutting of large muscle masses, are not necessary since recovery has been obtained following amputations at lower levels, even when lymphangitis or actual pus extended far above the incision. This success has been obtained both with and without sulfonamide drugs. This may be credited to refrigeration, but probably the drugs will be used as a routine in such cases.

Edema may be detrimental because of tension on sutures, by furnishing a culture medium for bacteria and especially because of pressure on an already feeble capillary circulation. It has been effectively checked by cold.

*Healing.* Most wounds from refrigeration amputation when tightly closed heal *per primam*, and the percentage of first intention healings is comparable to that after similar operations done under other anesthetics.[3] It has been emphasized, however, that refrigerated incisions heal more slowly than others, because of the known tendency of cold to inhibit agglutination of wound surfaces as well as an arrest of all other healing processes. Therefore, instead of the usual alternatives of prompt primary union or a breakdown followed by granulation, the surgeon encounters a new phenomenon, namely, a wound healing strictly *per primam* but requiring a multiple of the usual time. The skin sutures must not be removed until after the fifteenth or twentieth day.[11] It is impossible to force an activity of tissue beyond the limit set by its blood supply. Raising the temperature of the stump as rapidly as

possible promotes rapid healing, but this is not justifiable because of the risk of incurring sloughs. Slow healing is better than no healing at all. Postoperative wound drainage is usually more profuse, since refrigeration inhibits the agglutination of the wound margins. It has been observed that a raise in postoperative temperature after an amputation performed under refrigeration anesthesia is not as prolonged as after amputation under spinal anesthesia.

## INDICATIONS

Broadly speaking, refrigeration therapy has been advocated for three types of surgical lesions of the extremities: peripheral vascular disease with circulatory insufficiency, uncontrollable limb sepsis and severe trauma of the limbs with circulatory impairment. Arteriosclerotic gangrene has been the most frequent lesion in which refrigeration anesthesia has been used. Two distinct types of patients have been treated. When amputation is inevitable in non-toxic patients in poor general condition, the application of a tourniquet and refrigeration have provided a quick, satisfactory anesthesia within several hours, accompanied by minimal reaction to the operative procedure. On the other hand, if spreading sepsis predominates in the arteriosclerotic limb, permanent and continuous refrigeration may be employed for a period of days while the general condition is being improved.

There are many cases of early gangrene of the toes or a part of the foot due to peripheral vascular disease, especially among diabetic patients, in which a high amputation seems entirely too radical to the patient or to his relatives and consent is refused. Partial refrigeration of such an extremity, that is, chilling it by surrounding it with ice bags or cracked ice without the use of a tourniquet, has proved to be of therapeutic value. The metabolism in the extremity is retarded to the point that the gangrene may be checked and collateral circulation may have time to become established.[4] Richards doubts if any collateral circulation can be obtained by refrigeration.[21] If infection is present, this partial refrigeration inhibits bacterial growth, thus eliminating the spread of the infection. This method, especially when combined with the treatment of the peripheral vascular disease and the control of the diabetes, if present, may prove of the greatest value in limiting many amputations to the local area of gangrene or at least to the lower extremity instead of the routine thigh amputation as practiced by the majority.

Frequently, diabetic or arteriosclerotic patients have been so debilitated or so weakened by sepsis that they were poor operative risks. Many of them, sorely in need of amputation, have been allowed to die because experience and judgment warned against operation. Others have been so badly infected that their lives could be saved only by ridding them of the infected member. In these cases it has been the custom, in the past, to do a quick guillotine amputation in the calf, intending, if the patient survived, to do a finished amputation later, above the knee. Many of these stumps became infected, frequently with the gas bacillus. The patient frequently may go into diabetic coma or develop a generalized sepsis and die in spite of all therapy. It is in such cases that the tourniquet and refrigeration have been particularly valuable. The tourniquet stops absorption, while refrigeration inhibits cellular metabolism and retards bacterial action. Preoperative treatment is then of some benefit. A finished amputation at a site of election can then be done without much fear of stump infection. The absence of shock gives the patient a better chance to survive.

If the infection is very severe and threatening the life of the patient, the tourniquet may be placed above the site of infection and the part refrigerated for hours or even days. The simple packing in ice will often transform both local and general conditions and may check pain and the advance of

sepsis for perhaps several days.[4] When necessary, the tourniquet can give a still more decisive result, obviating the need for morphine and the waste of time and strength in preparing for operation. If applied promply by anybody on the resident staff, it will within a few hours permit an amputation without other anesthesia and with minimal shock. If the condition is so extreme as to make any operation inadvisable, the limb can be left for a few days or can be harmlessly amputated or disarticulated anywhere below the tourniquet in order to reduce the mass to be kept refrigerated. Later, when the patient's condition is improved to the point of standing an amputation, a second tourniquet may be applied about the thigh and refrigeration carried this high for two and one-half or more hours and the extremity removed. If this technic is carried out, the first tourniquet must never be removed.

Refrigeration offers advantages for nearly all cases of severe wounds of the extremities. Prevention and treatment of shock may be sufficient indications; surgical anesthesia is a valuable by-product. The suffering and blood loss from periodic loosening of an emergency tourniquet can now usually be avoided. Certainly, external applications of heat should never be used in conjunction with a tourniquet. Simple measures can and always should be instituted to help cooling whenever a tourniquet is applied. This is especially important in hot environments. Refrigeration anesthesia undoubtedly is destined to increasing use under civilian conditions as well as in war. In trauma of the limbs, for instance, which is common in war, refrigeration anesthesia may be of special service, not only in amputation, but also in the control of hemorrhage, pain, progressive shock and infection during transportation of the patient when adequate treatment cannot be applied on the spot. The methods of refrigeration anesthesia are being standardized. In the New York City Hospital a controllable electric refrigeration apparatus is in use.[2]

In badly crushed extremities, shock, often of an extreme degree, is present as the result of hemorrhage and absorption of histotoxins from crushed tissues. When a limb is so crushed that amputation is inevitable, the immediate application of a tourniquet and the packing of the limb in ice is advised.[4] This checks the shock and retards bacterial growth. It permits the surgeon a few hours to give the patient a transfusion and otherwise prepare him for amputation. Finally, the amputation can be performed without shock and without any other anesthetic agent whatever. McElvenny[23] reported a case of traumatic amputation in which ice was used preoperatively for fifty-eight hours without a tourniquet. The patient survived a bilateral thigh amputation.

*Military Wounds.* Allen and Crossman[15] have stated that tourniquet refrigeration provides freedom from pain, hemorrhage, shock and infection and allows either an immediate operation without other anesthesia or long deferment of operation without harm, if such a step is indicated. It is emphasized that the safe period for the application of the tourniquet is greatly lengthened by refrigeration. Refrigeration is usually available on naval vessels, and a 200-pound apparatus can be operated by the motor of a truck which will refrigerate four to six limbs simultaneously.[11] Bowers[16] has related favorable experiences in the treatment of patients with vascular trauma of the extremities encountered in a station hospital. He found the fluorescein circulation time test to be of value in the estimation of circulatory adequacy in refrigerated limbs. Criteria of failure of compensatory collateral circulation were listed.

*Miscellaneous.* Holman[17] suggests that in cases of limb trauma accompanied by concussion of the main artery with subsequent segmental arterial spasm, initial refrigeration enhances the survival of such a limb. In the immersion-foot syn-

drome, the principle of refrigeration has been employed to provide therapeutic cooling of hyperemic painful feet during the early stages. Such cooling without actual refrigeration has also been found useful in cases of frostbite.

Refrigeration anesthesia for skin grafting opens a new field for the use of reduced temperature in surgery. Mock[18] reported twenty-seven cases requiring small or multiple small split thickness skin grafts in which this method was used. Pinch grafts could be removed equally well, although none were attempted in his series. His results were reported as very satisfactory.

## TOURNIQUET

The use of a tourniquet is one of the great controversies in medicine. Most objections have centered about three points: The local asphyxia of the tissue distal to the tourniquet, the damage to the tissues compressed by the tourniquet and the shock produced by the release of the tourniquet. While there has been insufficient investigation to establish or refute these objections definitely, animal experiments have shown that bloodless extremities can survive twelve to fifteen hours at room temperature, without necrosis.[10] Crossman, Allen[19] and their coworkers reported one badly ulcerated human leg that had a tourniquet applied for six hours without apparent damage. Several days later this leg was amputated and pathologic examination likewise failed to demonstrate any damage from the six hours asphyxia. Direct pressure does injure tissues. The amount of damage depends on the tension, the elasticity and the width of the tourniquet. Naturally, only sufficient tension should be applied to stop the flow of blood. Elastic materials are less harmful than cords or other materials that will not expand. Except in the arm, where there are many nerves without much tissue padding, a narrow zone of constriction is preferable. Serious systemic shock has been produced by the release of a tourniquet that has rendered large masses of tissue bloodless for a long time. The histotoxins that form in asphyxiated tissues during the usual time a tourniquet is in place are insufficient to do this.[4] Badly traumatized tissues that have impaired local resistance are an exception. Here a tourniquet must be used guardedly unless it is in conjunction with refrigeration. Reduced temperatures obviate all the objections to tourniquets because the compressed or asphyxiated cells are at rest and are not throwing off waste products.[10]

The material for a tourniquet should be most elastic pure rubber tubing and the width should be the narrowest possible (perhaps 1.25 cm.),[2] because the wide bands in common use do not reduce the pressure needed at any one point but merely widen the zone of possible injury. Allen[2] and others state that the tightness must be sufficient to stop all flow of blood. In experiments, excessive tightness has proved to increase damage and danger, but there are no means of measuring the tension. It has been necessary that the errors should be on the side of excess and there has as yet been no clinical complication from this cause. The grossly exaggerated fears which prevail concerning the tourniquet have doubtless been due to the use of excessively tight, broad, inelastic bands, aggravated sometimes by elevated temperature.

These causes explain most of the unfavorable clinical effects attributed to tourniquets, such as paralysis, contractures, atrophies and tissue devitalization. There is reason to believe that a human limb can survive the stoppage of blood supply for as long a time as an animal's leg, namely twelve hours or more at ordinary temperatures.[2] After such a long period paralysis is inevitable, but it is transitory if the tourniquet has been properly applied, and the sequelae mentioned do not occur. This high resistance of a sound limb does not prove absence of injury. After such long asphyxia the

secondary inflammation is severe, and weak points such as recently healed wounds or tissues in the grasp of the tourniquet may break down. Even with shorter asphyxia, fresh wounds and infection create a highly dangerous complication, so that the devitalization may then be sufficient to threaten loss of the limb or even of life. The danger of constitutional shock increases with the mass of tissue ligated and the duration.[1,2,10] Therefore, these complications combine with the previously mentioned mistakes to give the tourniquet its bad reputation. In practical surgery there are two ways of avoiding these complications while obtaining the benefits of the tourniquet. One method has been emphasized especially by Crossman,[10] namely, a permanent tight tourniquet can be placed on a limb which is known to require amputation. The patient can thus be spared pain, hemorrhage, shock and infections, and the limb can be removed at or above the tourniquet whenever the care of a surgeon is obtainable. The decomposition of the part below the tourniquet does not endanger the patient, so long as the tourniquet remains tightly in place.

The tourniquet consists of two turns of a rubber tube to create the narrowest possible zone of compression. The clamp holding the two ends is kept from pressing on the skin by means of a gauze pad. Correct application of the tourniquet is one of the important details. As has been stated, empirical judgment has thus far been the only guide for the degree of tension, which should be the least that will positively stop all blood flow. Therefore, in some arteriosclerotic cases or in shock, this tension may be less than in the normal and much less than in a hypertensive patient. The rule that a tourniquet must not be applied to a diabetic or arteriosclerotic limb has been set aside by cold.[1] Just as the vessels of normal animals can tolerate a tourniquet for a day or two, so also the clinical experience thus far has shown no signs of serious or lasting damage to the most arteriosclerotic diabetic vessels by constriction up to five hours at a temperature near freezing.[1] But as excessively tight ligations produce ulcerations, paralysis and thrombosis in animals, similar consequences may reasonably be expected in humans. The practical experience indicates, however, that the margin of safety for these comparatively brief periods of only a few hours in patients, is so wide that there need be no extreme fear in applying a tourniquet with any reasonable care.[10]

## REFRIGERATION

The first clinical employment copied the procedure used in animals, by having the patient sitting up or propped up at a sufficient angle to allow the leg to be immersed in ice water to a level about one inch above the tourniquet. The advantages of this method were that the cold was maximal, reached every part of the skin and yet could not freeze the tissues. Next, weaker patients were allowed to lie with only a slight elevation of the head of the bed, and with the protection of a rubber sheet, the leg or thigh was placed on a layer of ice and covered completely with cracked ice. To obviate inconvenience and mess, a third step was taken by using ice bags. The thinnest and most flexible pure gum bags should be used, and three to five teaspoonfuls of salt added to each.

It has been suggested that the limb be first surrounded with a few ice bags at the level chosen for the tourniquet. Within five to fifteen minutes the skin is chilled so that the application of the tourniquet may cause scarcely any discomfort. If the limb contains any important amount of non-infected blood, it may be elevated to drain out as much as possible and the tourniquet applied while it is vertical. Immediately thereafter, the limb is completely buried in ice bags or cracked ice to a level several inches above the tourniquet. Any pain or discomfort quickly subsides under the influence of cold. A preliminary morphine hypodermic or other

sedative may be helpful on account of nervousness in some patients; but as far as anesthesia is concerned, no drugs are required. Whiskey is a good sedative for elderly arteriosclerotic patients.

Tests of the refrigeration should be made by occasionally inserting an ordinary laboratory thermometer between the various ice bags and the skin. Readings slightly above or below 5°C. assure the desired combination of adequate chilling and safety against actual freezing. A simple special apparatus for this purpose may be used but the use of ice or ice bags will permit of trials in any hospital or even under makeshift emergency conditions.

### ANESTHESIA

It has been noted that the time required for complete through-and-through anesthesia varies with the depth of tissue. It may possibly be as short as one hour for an emaciated shin or as long as five hours for a rather thick thigh. If it is not possible to cut the sciatic nerve at mid-thigh without attracting the notice of the conscious patient and without any change in pulse or blood pressure, there has been something wrong in the method of preparation. This physiological blocking of nerve conduction by reduction of temperature has some evident advantages over drugs employed either locally or systemically for this purpose.

### OPERATION

It is assumed that the tourniquet has been placed at the lowest level which will permit of preparing a sterile operative field and also not impede the sawing of the bone or other procedures. In the operating room the limb is removed from its nest of ice bags or cracked ice and the sterilization and operation completed as usual. No extraordinary haste is demanded, because the chilled tissues remain cold during an ample time for an ordinary operation. A rise of temperature does not affect the anesthesia, which is still thoroughly maintained by anoxia, but it is inimical to the perfect preservation of tissues and avoidance of subsequent shock. If saline solution is to be used for sponging or other local purposes, it should be iced. For any particularly long operation the limb may be kept on a bed of ice bags. Contrary to usual custom, the cooler the atmosphere of the operating room the better; and there is even the possibility that for operations lasting one to several hours the windows might be opened in winter or artificial cooling provided in summer.[1]

When all is in readiness for closure of the wound, the tourniquet is released. Circulation returns promptly, in a degree proportioned to the existing arterial supply, and bleeding points, usually eight or ten in number, can be caught and ligated. The anesthesia then continues at least long enough for convenient completion of suturing.

Our experience has corroborated Allen's findings as regards the condition of the tissues seen in stumps of legs amputated under refrigeration anesthesia. The skin is blanched but fresh. The muscles are bright red and have a fresh appearance. The blood vessels are wide open, and when the tourniquet is removed fresh red blood flows freely from them, indicating the absence of all thrombosis. As stated by Allen:[2] "The tissues have the appearance of a leg of beef which has hung in a refrigerator for days."

### DRAINAGE

The technic employing silk or cotton without drainage is the ordinary rule, but anything from small drains to a wide-open wound may be adopted, according to the degree of infection. Unfavorable tissue reaction to drains is prevented by cold. The character of the discharge, also, is noteworthy. Even if it is dark, thick or putrid at the outset, it soon changes to a profuse, thin, serous liquid, colored bright pink with hemoglobin. Cold prevents sealing of the wound edges and pocketing of exudate. Closely apposed flaps thus

may remain ununited and irrigated from within as long as chilling is continued. Whenever it is desired to stop the drainage, elevation of the temperature results in rapid agglutination of the margins of the wound.[2]

### NECROSIS

The theory of this point is that nothing can be done to increase greatly the supply of blood, but reduced temperature can greatly reduce the need of the tissues for oxygen and food. Fears of a corresponding contraction of arteries reducing the blood flow have not been substantiated. Also, a reason should be found for the familiar gangrene or failure of healing in amputations below the knee, even when the unwounded calf tissues appear to be in no danger of gangrene. This reason may be found, theoretically, in postoperative inflammation, with a demand for hyperemia which cannot be met by vessels barely adequate for ordinary nutrition.[2] Both the exaggerated inflammatory need and the ordinary resting need of the tissues for blood have been reduced by cold.[1,2,4,8] Therefore, necrosis may be prevented and sound healing obtained; if the circulation is inadequate, necrosis is limited and slow, and re-amputations are easily performed without deaths. There is thus greater freedom in selecting low levels of amputation if desired for either local or systemic reasons.[2]

### THROMBOSIS

Spreading thrombosis, sometimes extending rapidly up a limb and entailing a correspondingly rapid gangrene, has been found to be due to damage of the vessel walls, arising from bacterial action in infectious cases, from lack of nutrition and oxygenation in pure arteriosclerotic cases, or often from combinations of these two cases.[1] Cold acts directly to retard clotting as evidenced by the absence of coagulation in the ligated refrigerated limbs of animals.[13] It is presumably due not so much to an inhibition of the clotting process as to a preservation of the vessel walls by cold. As bacterial activity is also prevented or retarded the danger of thrombosis should theoretically be avoided or minimized. This expectation seems to be fulfilled by the absence of any sign of this danger in the reported experiences thus far. This principle may, therefore, prove useful, in addition to heparin, for the treatment of other conditions in any accessible part of the body.[1]

Several patients with deep venous thrombosis of the lower extremities, all candidates for ligation and division of the femoral vein, according to the usual requirements for such a procedure, have been treated by local chilling of the tissues, as reported by O'Neill.[3] All improved without further treatment. This observation is not particularly convincing, since many such patients improve with rest alone. It may be of value, however, in suggesting that prolonged cold, without freezing, inhibits thrombosis. O'Neill stated, however, that his preference in the treatment of deep venous thrombosis, is still in interruption of a proper deep venous channels.

### AFTER-CARE

The guiding principle of postoperative management has been to reduce the temperature to whatever extent may be necessary but to raise it as fast and as far as may be safe. Following operation, it has been recommended that refrigeration of the stump may be maintained by means of ice bags against a thin dressing, gradually reducing the refrigeration over a period of several days. In patients with an adequate blood supply, there is no objection to letting the stump return immediately to normal body temperature. The abundant proof of normal healing in animals by this method has been duplicated in the small human experience including both thigh and calf. But by means of temperature regulation a whole series of important new controls have become

available when needed, as noted by Allen:[1]

"1. When there has been threatening signs of loss of vitality in wound flaps or mutilated tissues, the surgeon heretofore has stood helplessly by and watched slough. The sloughing is obviously due to a deficient nutrition, especially oxygen. There is no means for an immediate and effective increase of blood supply, but it is immediately possible to reduce the tissue metabolism to a level for which the existing blood supply is adequate. When necessary the temperature can be lowered to a point at which tissues can survive for a considerable time without any circulation. Some experiences indicate that such control can actually be maintained during the critical period until the circulation improves.

"2. If operation, shockless in itself, has left damaged tissues which may set up postoperative shock, especially in a weak patient, this danger period can be bridged by temperature control. Shock production by tissues is inhibited in proportion as their temperature is reduced. The temperature may be raised gradually accordingly as the local tissue vitality and the constitutional state may permit."

"3. A fundamental problem of surgery is created by the tendency of wound edges to agglutinate and thus seal up collections of fluid which are liable to become decomposed or infected. With refrigeration just as with other forms of anesthesia, it has proved possible to close wounds completely without drainage under favorable conditions, as in the thigh.[1,2,3,4,10] But diabetic or arteriosclerotic limbs commonly present special difficulties, because of the dangers of pressure from close coaptation of the edges, while drains have recognized disadvantages including the irritant action of the foreign body. It is known from animal experiments that the most active of all agglutinating processes, namely, that the peritoneal surfaces and especially of the omentum, is completely inhibited by cold. Human operations have added the information that agglutination and drainage in wounds can be similarly controlled. For an undetermined length of time, certainly for a number of days, the wound margins can be kept healthy and in close approximation, yet not sealed. Discharge may continue abundantly; and even if it is dark at first because of the state of the tissue, it rapidly changes under cold. It cannot decompose or become infected because enzymes and bacteria are checked by the low temperature. By raising the temperature at any time the wound margins can be made to agglutinate within a few hours and the exudate assumes the usual character or ceases."

Two definite errors have been responsible for any slight blistering or necrosis that has been encountered thus far. One was reduction of temperature to the point of actual freezing. The other was pressure. It is necessary to bear in mind that pressure injures tissues, especially if they are bloodless and at abnormal temperature; and while there is remarkedly good tolerance of the severe pressure of a tourniquet for a considerable time, perhaps because of a protective influence of thorough chilling, there is a possibility of ulceration from the minor pressure of ice bags or bandages. Although these dangers are readily avoidable and have not proved serious, they must be borne in mind.[8]

Crossman, Ruggiero, Hurley and Allen,[7,8] analyzed their results in 101 amputations with refrigeration anesthesia. The mortality rate in this series was 15 per cent. McKittrick[6] stated that the mortality rate in amputation for diabetic gangrene ranges from 13 to 80 per cent. Considering only the diabetic cases in the Crossman series, ten deaths out of forty-seven patients with an average age of sixty-five years, the mortality rate rises to 21 per cent. Glassner[22] reported an over-all mortality rate of 38.8 per cent. Of these only two were due to operative interference which leaves a mortality rate of 11.1 per cent.

In our small series of twelve cases there were two deaths; the first was due to a pulmonary embolism on the seventh postoperative day, and the other was due to a streptococcic septicemia, the patient living sixteen days after operation. This leaves an over-all mortality rate of 16.6 per cent. All of our patients had supracondylar amputations, performed according to a modification of the Callander technic. (Table I.)

Pain is relieved in most instances after the application of cold, thus adding to the ease and comfort of the patient as well as facilitating preoperative preparation. The postoperative period is likewise free from pain, and the patient may carry on without missing a meal. This is especially important in diabetics as the diet and insulin do not have to be changed.

There is ease and quickness of operation in these cases. Poorly nourished tissues may be saved although refrigeration will not restore devitalized tissue. Edema and drainage may be controlled postoperatively when necessary. There is also a reduction in the incidence of thrombosis and embolism.

This method of anesthesia is also valuable in severe crushing wounds of the extremities or other injuries that require amputation.

This form of refrigeration is not intended to supersede other forms of anesthesia when the general condition of the patient is good, but is a valuable adjunct in the treatment of the poor risk patient.

TABLE I

| Hospital Number | Date of Operation | Age | Sex | Race | General Diagnosis | Local Condition | Patient's Condition | Operation | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 16701 | 4/22/44 | 78 | F | W | Arteriosclerosis diabetes mellitus | Gangrene left foot infection | Very poor | Left supracondylar amputation | Stump incompletely healed at discharge |
| 50651 | 5/8/44 | 75 | M | W | Arteriosclerosis diabetes mellitus | Gangrene left foot | Fair | Left supracondylar amputation | Healed per primum |
| 92220 | 11/18/43 | 78 | F | W | Arteriosclerosis peripheral vascular disease | Gangrene embolism femoral artery | Poor | Left supracondylar amputation | Died 7 days, postoperative pulmonary embolism |
| 22259 | 3/16/44 | 79 | F | W | Arteriosclerosis diabetes mellitus | Gangrene right foot | Poor | Right supracondylar amputation | Healed per primum |
| 22259 | 2/4/43 | 79 | F | W | Arteriosclerosis diabetes mellitus | Gangrene left foot | Poor | Left supracondylar amputation | Healed per primum |
| 89377 | 10/5/42 | 56 | M | W | Arteriosclerosis vascular disease | Gangrene left foot lymphangitis | Poor | Left supracondylar amputation | Lymphangitis and cellulitis stump skin grafting |
| 89424 | 10/5/42 | 59 | M | W | Arteriosclerosis | Gangrene left foot | Fair | Left supracondylar amputation | Healed per primum |
| 36338 | 3/15/43 | 58 | F | W | Arteriosclerosis diabetes mellitus | Gangrene left foot ascending lymphangitis | Very poor | Left supracondylar amputation | Died 16 days postoperatively streptococcic septicemia |
| 25840 | 6/28/44 | 54 | M | W | Bronchial asthma peripheral vascular disease | Gangrene right foot | Poor | Right supracondylar amputation | Slough of stump |
| 25840 | 7/7/44 | 54 | M | W | Bronchial asthma peripheral vascular disease | Slough stump | Poor | Amputation lower ⅓ right femur | Healed per primum |
| 20496 | 7/19/43 | 67 | F | W | Arteriosclerosis diabetes mellitus | Gangrene right foot | Poor | Right supracondylar amputation | Healed per primum |
| 20496 | 9/3/44 | 68 | F | W | Arteriosclerosis diabetes mellitus | Gangrene left foot | Poor | Left supracondylar amputation | Healed per primum |

## SUMMARY

The use of refrigeration anesthesia for major amputations of the limbs is a sound surgical procedure. It is applicable in particular to the poor risk patient since there is scarcely any shock accompanying the procedure. It is possible to perform major amputations safely with this form of anesthesia in what formerly were hopeless cases because of debility or septicemia. It lowers the incidence of stump infections in those patients requiring amputation because of infection.

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In a severely shocked patient whose blood pressure is already low, a further fall may lead to a cerebral anaemia of such degree as to depress the vital centres beyond the limits compatible with life. Therefore, it is absolutely contraindicated to administer a spinal anesthetic to a wounded patient who is suffering from shock.

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# HYPOPROTEINEMIA IN SURGERY OF THE THORAX

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EVALUATION of protein levels in chest surgery has not received as much analytical attention as in the field of abdominal operations. With the increasing value and realization that a low blood protein level is not only of metabolic interest but also a factor of operative morbidity and even mortality, much such investigation into protein shift, levels, and dynamic chemistry has been studied in the past three or four years.

The concepts of Donnan equilibrium, Starling's Law of oncotic pressure, and even the rôle of the liver as an active factor in protein dynamics have been altered not only in theory but also in its relations to therapy.

Recent work suggests that protein molecules will even diffuse through cellular membranes maintaining a balance between intrinsic cellular metabolism and the cellular fluids bathing them. The clinical application of this experimental fact has far and wide reaching implications.

The value of protein maintenance in normal wound healing with its attendant fibrinogen necessity, and even the nonspecific globulin and albumin aids to immunological response and local tissue healing has been rather voluminously reported. Clinically, a total protein value of below 5 Gm. per cent will find healing markedly impeded; and as one goes down the scale gaping of fascial planes, herniation, and finally evisceration are the inevitable aftermaths.

The attendant cardiorenal dysfunction below a total protein value of 5 Gm. per cent and an albumin value of below 3.2 Gm. per cent will yield a final anasarca. Even a patient who is a good surgical risk undergoing an emergency appendectomy with attendant little trauma will still demonstrate postoperatively a fall of protein varying from 1 to even 1½ Gm. in the first forty-eight hours. All things being equal, he will resume his normal protein balance in about ten days. However, even here, the incalculable but ever present loss of protein from operative trauma, minimal though it may be, to a serous membrane (the peritoneum) is evidenced by the oft-repeated above findings. The more severe the operation the more the postoperative drop, though most operative procedures without excessive loss of blood, postoperative fistulas, or drainage of the peritoneal cavity will usually stay above the critical protein levels before mentioned. It is well to remark that in all cases that because of the small molecular weight and its twofold greater abundance the albumin is always the first fraction that is observed lost, and also the figure that has finally gone the lowest. The globulin factor itself, increasing as it does with infections, will usually make its evaluation in protein shift and levels difficult in the integration of this protein inbalance.

Realizing the import of all factors in their inestimable and imponderable value in safely guiding a patient through his hospital stay with a difficult operation and intricate postoperative care, protein metabolism and its implication to thoracic surgery have been studied.

Surgery of the thorax differs in many respects from general, and specifically, abdominal surgery. Though it be true that technical skill, anatomical familiarity and clinical judgment must be tempered by diagnostic conundrums in both cases, yet

there is a distinct schism between the two fields.

A laparotomy entails no problem of disturbed physiology of vital organs and the unpredictable effects on different individuals with the same procedures. Mediastinal shift with its attendant effect on the cardiorespiratory mechanism, the exposure of extremely large serous surfaces to air trauma, and increased (atmospheric) pressure, the prolonged nature and time of operation of all intrathoracic operations, the interference continually with vital tissues in their normal balance and conductivity of fluid flow and impulse transmission, the necessity for positive pressure anesthesia with its coincidental effect on medullary centers and cerebral anoxemia, the repeated chronicity of most thoracic operations which are seried investigations and the attendant poor morale and physical condition of the patient—all these make every factor, even though minute, of infinite import in chest surgery.

Attempting to anticipate blood loss by transfusion preoperatively and on the table, using wet hot towels, skin protection to reduce surface fluid loss and minimize infection, plus anesthesia by intratracheal insufflation to control respiratory quotient and balance are means adopted to overcome a necessary nitrogen inbalance. Exactly what demands are made on protein reserve in the liver, body tissues, and circulating blood volume by fluid shift, terrific metabolic needs with attendant breakdowns of non-storage, vital organ needs in thoracic surgery is hard, or at times impossible to calculate, and even arbitrarily to anticipate. Particularly is this true when one realizes that all of these illnesses being chronic, there is necessarily some degree of amyloidosis and fatty degeneration of the liver and other potential storage depots. Such livers and tissues thus store and metabolize less protein even when an abundance is given them at some future date. Liver function tests with the Congo red, hippuric acid, prothrombin, cephalin or blood protein levels are only relatively accurate when one realizes the immense reserve of such organs.

Rapid replacement of protein is, however, still all too frequently an emergency. It is difficult for one to realize that a thoracotomy tube draining an average acute empyema or postoperative pleural effusion will remove a sizeable amount of protein from the blood in twenty-four hours. The average amount of protein will vary from a minimum 3.6 per cent to a maximum of 7 per cent. The quantity of fluid varies from 350 cc. to as much as 4,000 cc. daily in postoperative effusions depending upon the type of operation, degree of atelectasis, previous protein inbalance, fluid loss and replacement during operation and complications postoperatively which ensue. This loss of pleural fluid and the outpourings of all serous surfaces is probably one of the largest factors in the rôle of hypoproteinemia in chest cases. Particularly, one must realize that ascitic fluid will vary from 1 to 3 per cent depending upon the length, type, and extent of hepatic cirrhosis, whereas all pleural effusions vary from twice to three times this amount continually. A patient postoperatively who has a pleural effusion of 2,500 cc. drained off or even left in the chest cavity has a loss of almost half of the circulating blood protein. Replacement by exogenous sources must, therefore, be incessant since endogenously it can be supplied only as an emergency or replacement therapy.

Checking the urinary albumin we know that for every Gm. of albumin in the urine, 30 Gm. of body proteins must be broken down. Thus the blood protein value is of sheer necessity the difference all too frequently between autonomic cannibalism and bodily survival. In extreme cases this progressive depletion of circulating blood protein due to the continual loss of protein from weeping, inflammatory and secreting surfaces continues. Then the liver falls into a vicious cycle of adding to its already overtaxed vital reserve the necessity of increased formation of albumin and globu-

lin. The source of added protein increment now comes from endogenous breakdown and frenzied, forced exogenous intake. The inevitable happens as witnessed in Cases I and XIII. The progressive downhill courses of these patients are paralleled by their increasing hypoproteinemias. Once these inflammatory processes in the pleural cavity are well under way and protein inbalance obtains, restoration of normal values are most difficult to restore and maintain despite intravenous amino acids, plasma and high protein diets.

The balance of protein is obtained roughly through the interplay of four factors: (1) The exogenous source (food); (2) the synthesis of albumin, globulin and fibrinogen by the liver after protein breakdown and amino acid splitting; (3) loss of protein through increased metabolism and pathological continued inflammation (effusion and empyema), and (4) the excretion, mainly urinary albumin.

In thoracic surgery all of the above factors are vitiated. Even before operation and sometimes the immediate decisive factor for rapid recourse to operation are the peculiar pathological processes in the thorax along with its minion, hypoproteinemia. For if the patient has a cancer of the esophagus the food intake is diminished, the liver is affected as part of a malignant toxic depression, and so protein imbalance effected. The kidney's excretion is now impaired since liver formation of urea is diminished, and with diminished protein a lowering of the oncotic pressure in the blood obtains. Fluid resorption in the tubules now is faulty. Finally, with this progressive damage to the kidney, loss of albumin accurs. Here, we have a progression of events involving merely a conducting tube (esophagus), but with a thoracic location. Operation of a patient with this condition adds the problem of opening a thorax with further loss of pleural surface, blood loss and all the superimposed factors, which further push the patient down the road toward an increasing hypoproteinemia.

The chronic cases with draining pleural surfaces offer a divergent problem. Here one can assume that a thoracotomy tube will drain an overall average of from 1,000 cc. per twenty-four hours, for the first three or four days after its introduction into the offending thoracic fluid accumulation.

With a minimum protein of about 4 per cent the patient is losing per day a protein content equivalent to between 500 to 600 cc. of circulating blood volume per day, or roughly 10 to 12 per cent of his total plasma protein. Normal protein values of 7½ Gm. per cent obtaining, it could take some sixty hours to reach a critical level of 5 Gm. per cent were it not for replacement by liver and tissue cell protein reserves.

However, these endogenous sources supply only a small, and at that, a transient replacement. With the obvious poor gastrointestinal digestion and assimilation of such debilitated or postoperative patients, but little exogenously of protein content will help this increasing negative nitrogen balance.

The use of blood transfusions, plasma, amino acids by mouth or parenterally, must be employed to augment protein intake. By far the most expedient and economical protein replenishment is intravenous or intramedullary use of amino acids. Amino acids for usage are divided into two classes, both being digests of 10 per cent casein. One is an acid hydrolysis with the addition of tryptophane to the final product and the other is an enzymic digest; the latter needs no addition of tryptophane but offers the disadvantage of possible side and allergic reactions through the presence of peptones and polypeptides.

The amino acid therapy consists of 60 to 90 Gm. daily given through the intravenous route. If the enzymic preparation is given, the sugar concentration in the diluting fluid must be higher than any hydrolytic preparation of amino acids. As a general rule a 10 to 15 per cent coverage of glucose in saline in resultant

TABLE I*

| Operation | Preoperative | Postoperative | |
|---|---|---|---|
| | | Immediately | Following |
| *Case I (W. H.)* | | | |
| Lobectomy | | | |
| Total protein | 7.95 | 5.92 | 4.30 |
| Albumin | 6.00 | 4.40 | 2.20 |
| Globulin | 1.95 | 1.52 | 2.10 |
| Ratio | 3.07 | 2.90 | 1.05 |
| *Case II (R. Z.)* | | | |
| Thoracoplasty | | | |
| Total protein | 7.50 | 6.60 | 6.00 |
| Albumin | 5.50 | 4.20 | 3.00 |
| Globulin | 2.00 | 2.40 | 2.20 |
| Ratio | 2.75 | 1.75 | 1.73 |
| *Case III (J. G.)* | | | |
| Esophagogastrostomy (Megaesophagus) | | | |
| Total protein | 8.50 | 6.25 | 8.00 |
| Albumin | 6.00 | 4.25 | 5.00 |
| Globulin | 2.50 | 2.00 | 3.00 |
| Ratio | 2.39 | 2.13 | 1.67 |
| *Case IV (L. L.)* | | | |
| Plastic Revision of chest (Thoracoplasty) | | | |
| Total protein | 7.00 | 6.15 | 7.20 |
| Albumin | 4.50 | 3.50 | 3.90 |
| Globulin | 2.50 | 2.65 | 3.30 |
| Ratio | 1.80 | 1.52 | 1.18 |
| *Case V (L. McK)* | | | |
| Thoracoplasty | | | |
| Total protein | 6.25 | 4.00 | 7.00 |
| Albumin | 5.00 | 3.00 | 5.00 |
| Globulin | 1.25 | 1.00 | 2.00 |
| Ratio | 4.00 | 3.00 | 2.00 |
| *Case VI (L. J.)* | | | |
| Ant. Thoracoplasty | | | |
| Total protein | 8.50 | 6.50 | 5.75 |
| Albumin | 3.60 | 3.00 | 3.50 |
| Globulin | 4.90 | 3.50 | 2.25 |
| Ratio | 0.76 | 0.80 | 1.50 |
| *Case VII (S. C.)* | | | |
| Thoracoplasty | | | |
| Total protein | 7.00 | 5.50 | 7.00 |
| Albumin | 5.00 | 3.50 | 5.00 |
| Globulin | 2.00 | 2.00 | 2.00 |
| Ratio | 2.50 | 1.75 | 2.50 |
| *Case VIII (E. McG)* | | | |
| Thoracoplasty | | | |
| Total protein | 6.50 | 5.50 | 7.20 |
| Albumin | 4.00 | 4.50 | 4.20 |
| Globulin | 2.50 | 2.00 | 3.50 |
| Ratio | 1.60 | 2.15 | 1.40 |
| *Case IX (M. K.)* | | | |
| Thoracoplasty | | | |
| Total protein | 5.00 | 4.50 | 5.50 |
| Albumin | 2.50 | 2.50 | 3.50 |
| Globulin | 2.50 | 2.00 | 2.00 |
| Ratio | 1.00 | 1.25 | 1.75 |

TABLE I* (*Continued*)

| Operation | Preoperative | Postoperative | |
|---|---|---|---|
| | | Immediately | Following |
| *Case X (M. V.)* | | | |
| Thoracoplasty | | | |
| Total protein | 7.60 | 6.50 | 6.20 |
| Albumin | 5.50 | 4.80 | 4.20 |
| Globulin | 2.10 | 1.70 | 2.00 |
| Ratio | 2.62 | 2.82 | 2.10 |
| *Case IX (W. S.)* | | | |
| Thoracoplasty | | | |
| Total protein | 7.00 | 6.50 | 5.50 |
| Albumin | 5.00 | 4.50 | 2.50 |
| Globulin | 2.00 | 2.00 | 3.00 |
| Ratio | 2.50 | 2.25 | 0.83 |
| *Case XII (J. G.)* | | | |
| Plastic revision of chest wall with rib resection | | | |
| Total protein | 6.80 | 6.00 | 7.20 |
| Albumin | 4.00 | 4.00 | 4.50 |
| Globulin | 2.80 | 2.00 | 2.70 |
| Ratio | 1.43 | 2.00 | 1.69 |
| *Case XIII (H. S.)* | | | |
| Closed thoracotomy | | | |
| Total protein | 5.52 | 4.40 | 3.00 |
| Albumin | 2.40 | 1.90 | 1.00 |
| Globulin | 3.12 | 2.50 | 2.00 |
| Ratio | 0.77 | 0.76 | 0.50 |
| *Case XIV (C. R.)* | | | |
| Open Thoracotomy | | | |
| Total protein | 7.75 | 6.50 | 8.00 |
| Albumin | 6.00 | 4.00 | 5.00 |
| Globulin | 1.50 | 2.50 | 3.00 |
| Ratio | 4.00 | 1.60 | 1.67 |
| *Case XV (S. R.)* | | | |
| Cavernostomy | | | |
| Total protein | 7.20 | 5.80 | 5.80 |
| Albumin | 4.30 | 3.50 | 2.50 |
| Globulin | 2.90 | 2.50 | 3.30 |
| Ratio | 1.48 | 1.75 | 0.76 |

* An analysis of the protein figures in the above table demonstrate several pertinent and definitive conclusions: (1) All protein values drop postoperatively. (2) Their return to normal or the normal level for that patient who has had a diminution in vital capacity and other organ reserve depends upon two things: (a) the degree of damage to vital organs the patient has already had due to his offending pathological condition or previous operative insults; (b) the type and severity of operation instituted. (3) Seried operations such as thoracoplasties of a three-stage nature place a much greater drain upon metabolism of the body, especially protein, than is probably recognized since it will be noted that in such cases such a No. II, VI, V, VIII, X, a return to a preoperative protein balance does not obtain. (4) Where patients have a loss of fluids and protein through draining thoracotomies or sinuses, loss

solution after the dilution with the amino acid preparation of an enzymic nature must be observed. With the hydrolytic preparations of amino acids, a 5 per cent glucose in saline or less may be used with impunity without untoward actions. In both slow drop of 40 per minute must be observed. By this amino acid administration the average postoperative protein drop will be slowed and eventually return to protein balance of a positive nature. The evaluation of a positive protein balance may be done by juggling the blood protein levels daily against the twenty-four hour urine specimen's total protein content. The latter calculated as protein per unit specimen times the total amount of urine will give the daily protein loss in the body. Its replacement is completely necessary to keep total protein levels above the critical level of five, and an albumin level of three. In addition, some 1½ Gm. per kilogram of body weight of protein orally, the liberal use of vitamin B and C must also be given for intestinal assimilation and balanced with vital organ function. A high caloric intake with a moderate fat composition must also be administered.

Evidence of critical protein levels and patients with post-pneumococcic empyemas transferred from medicine was one of the convincing factors in the justification and the investigation of protein metabolism in thoracic surgery. Here the patient's loss of protein into his own thorax was not recognized; and his subsequent downward course not halted, and accordingly not properly treated. The entire fatal problem in these cases was blamed on the illness itself and the subsequent attendant debility of poor oral ingestion of food intake. Postoperatively anasarca of our patients was also observed until a régime of calibrated protein replacement was established.

We are attempting in this article to demonstrate by an unpicked series of cases the defects in early recognition and treatment of protein imbalance. At this hospital all of our cases comprise the poor risks; the effects of mismanagement at other places of medical care, the patients who have had many and crippling operations, the indigent who have been unable to secure proper care and sustenance between periods of medical attention, the gyriatric with their catabolic complications, and the far advanced pulmonary tubercular patient. In our series we have patients admitted with one kidney, bilateral tuberculosis, megalo-esophagus complicated with tuberculosis, thoracoplasties with thoracotomy drainage of empyema cavities, thoracoplasty complicated with carcinoma on the opposite side, and tuberculosis with peptic ulcer.

The thoracic surgical patients represent more possibly the single largest major group of chronically ill patients who may somehow be helped surgically. Concomitantly, the very nature of their illness represents one of the largest groups who can be helped most by attention to this insidious and incessant breakdown of body and tissue protein occurring through the prolonged severe nature of their illness and the corrective operations.

This group of patients may be lumped into a classification of the pneumococcic tuberculosis designation with the complications of these two pathological processes. It is to be reiterated that with this type of prolonged illness the patient will exhibit not only a faulty ingestion due to continual anorexia, but also poor assimilation of protein through constant debilitation. The vicious cycle thus obtains of a body injured by depletion of protein being unable to take care of the protein it so seriously needs. And then the addition of traumatic insults through operation is added. The following cases represent the series done

of fluid into the pleural cavity such as empyemas or pleural effusions preoperative protein normalcy takes an indefinite period of time to assume normality. Witness cases No. II, III, VI, IX, XII, and XIII. (5) Prognostication as to the ultimate fate of the patient may be correlated with rapid protein imbalance. When total protein falls below five and the albumin falls below three with a relative increase in globulin, reversing the A/G ratio, that patient's ability to survive ceases as in the cases I and XIII.

from January, 1944, to date. They run through the gamut of the minor surgical operation of a closed thoracotomy for underwent a lobectomy expired due to complication of tremendous postoperative pleural effusion which depleted her protein

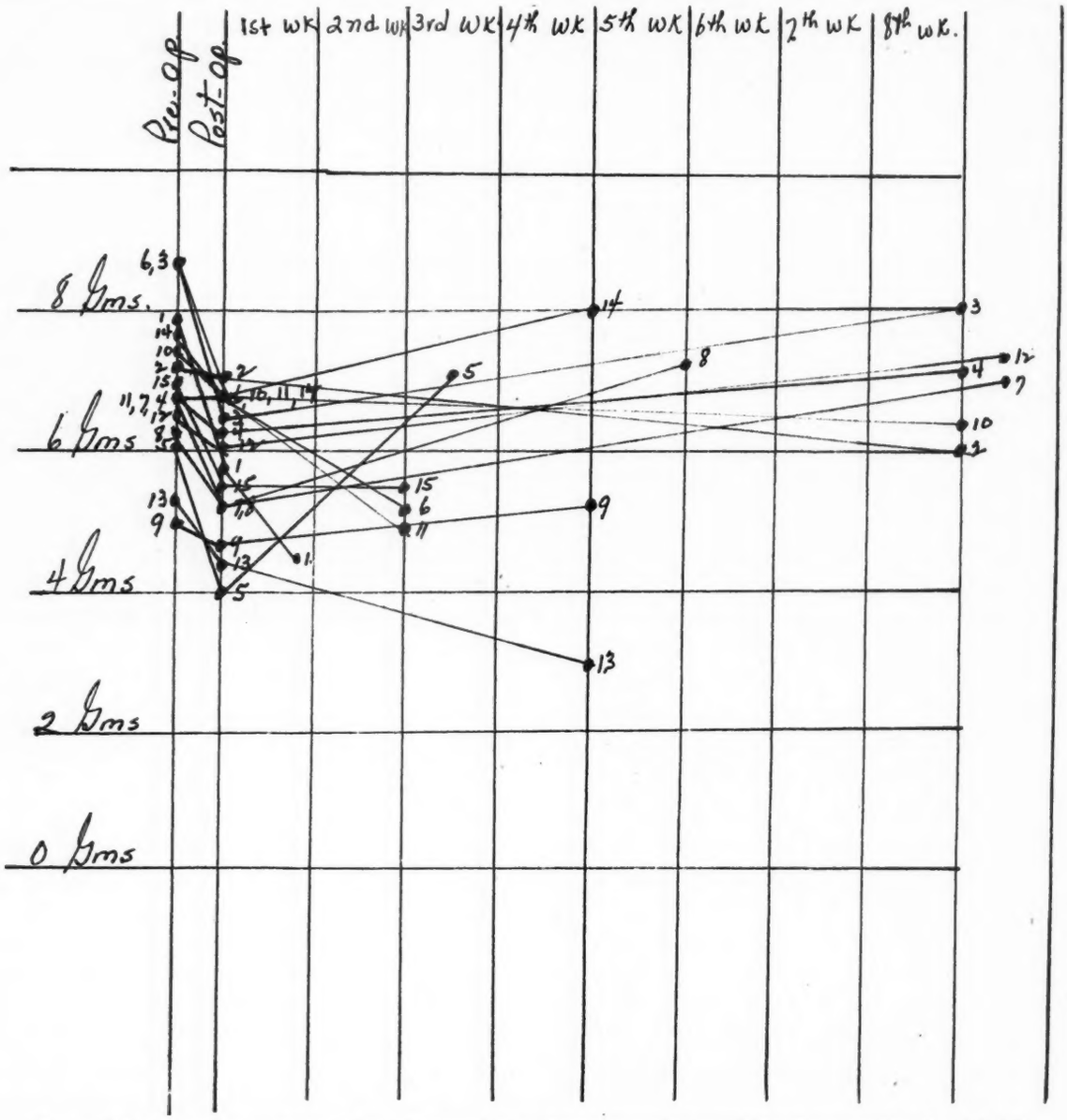


FIG. 1. Fifteen cases are charted for preoperative and postoperative total blood protein levels.: (1) All but four cases returned to normal preoperative values by two months. (2) Two cases which fell below the preoperative values after operation and continued downward expired. (Critical values of albumens below 2.50, total proteins below 4.50 obtained.) (3) Two cases did not return completely to preoperative levels because of intervening operative procedures. (4) One case with bilateral advanced tuberculosis after cavernostomy still below normal. (Two weeks postoperatively—time of writing of paper.)

empyema to the extensive operations of lobectomy and esophageal gastrostomy for megalo-esophagus. The two patients who expired in this series represent extreme instances of variation in the magnitude of surgical technic. The first patient who reserve below a critical level despite massive continual blood transfusion replacement. Case XIII represents the result of inadequate treatment of a pneumococcic empyema with the lack of recognition of a protein loss which the patient was losing

into his own chest cavity. The cases to be presented follow:

## CASE REPORTS

Case I. A thirty-nine year old white female had post-pneumonic right upper lobe lung abscess. Pneumonostomy drainages had been done. Following this, recovery obtained with the removal of tubes, closure of the external wound and clinical and symptomatic improvement. The patient returned with a story of chills in the back, hemoptysis, bouts of dyspnea, and fatigue.

Physical examination revealed a well nourished, robust, ambulatory, non-febrile non-dyspneic female. The trachea was in the midline. There was no cervical adenopathy. The apex beat was at the fifth interspace, mid-clavicular line, and there were no murmurs. A small cicatrix at the third interspace anteriorly on the right side was completely healed. Breath sounds and percussion note throughout both sides were essentially within normal limits. The extremities showed no clubbing, cyanosis or edema.

Impression: A residual healed lung abscess cavity (lung cyst) of the right upper lobe.

By means of standard *x*-rays of the chest, tomagraphic studies and bronchography, two cavities occupying the lower half of the right upper lobe and located about 14 cm. from the posterior chest wall were observed.

The patient was operated in February for right upper lobectomy. A large epithelialized lung cyst communicating with a patent bronchus in the right upper lobe was found and removed *in toto* as part of the lobectomy. The patient developed a profuse pleural effusion which drained through the thoracotomy tube inserted at the time of operation in the sixth interspace. A secondary bronchopneumonic process of the lower part of the left upper lobe obtained and on the fourth day the patient expired.

Postmortem findings showed an atelectasis of the right middle lobe, a partial atelectasis and bronchopneumonic process of the right lower lobe and a bronchopneumonic process of the lower part of the left upper lobe.

Case II. R. Z. was admitted to the Tuberculosis Pavilion on February 3, 1944, and was admitted to the Thoracic Surgery service on February 8, 1944. He was a thirty year old white male with a history of tuberculosis, left side, with cavitation since 1936. The patient then had pneumothorax at Bellevue, and had in succession Jacobeus, and phrenic nerve crush, spontaneous pneumothorax, and then effusion and empyema with a thoracotomy. He had three stages of thoracoplasty starting in 1938 to date. He was discharged and then returned with a sinus tract. He again had empyema which had another thoracotomy done. He had had three stages of plastic revision for chronic empyema.

Physical examination revealed a bedridden patient, markedly anemic, toxic, with moderate dyspnea and febrile. The heart showed a slight systolic murmur. The apex beat was displaced to the right side about 2 cm. in the sixth interspace. There was normal resonance on the right side with breath sounds increased in pitch and intensity. There was swelling of the left side of the chest wall from about the ninth interspace in the mid-axillary line and running downward and posteriorly just above the iliac crest. There was flatness over this area and the lung fields on the entire left chest except for the clavicular region with no breath sounds. The extremities showed slight clubbing of the fingers, but no unusual cyanosis or edema.

Impression: Tuberculosis of the left lung with chronic empyema, probably postdating the original pneumothorax treatment and not obliterated after the thoracoplasty procedures.

A small incision was made over the ninth interspace, mid-axillary line, and a tube inserted into and through the chest wall into the empyema cavity. A gush of 200 to 300 cc. of yellowish-brown turbid fluid without odor obtained. The tube was connected with underwater drainage. Further operations were then done to unroof and obliterate the empyema cavity. The first stage revision thoracoplasty was performed in March 2, 1944, the second on April 6, 1944, and the third stage revision thoracoplasty on May 11, 1944.

Case III. J. G. was admitted March 8, 1944 and discharged May 15, 1944. The total hospital stay was sixty-eight days, the post-operative stay fifty-six days. The patient was a twenty-nine year old colored male with a history of left pulmonary tuberculosis. Sputum was always negative, even at Otisville during a three-months' stay. The patient had trouble swallowing and stomach trouble. Diagnosis: Ulcers for about one and a half years. He had regurgitation after each meal which be-

came progressively worse. There was no cough or hemoptysis. This condition was discovered in a routine chest examination one week after admission to Otisville.

Physical examination revealed an attenuated colored male, 5 feet 11 inches tall. The heart revealed no murmurs; it was regular in outline and size. The apex beat was at the sixth interspace. There was some dullness in the left apex of the lungs but no râles or change in breath sounds. The abdomen was scaphoid in shape. The extremities were not clubbed or cyanotic.

Impression: (1) Achalasia esophagus; (2) cardiospasm; (3) tuberculosis? left apex.

Esophagogastrostomy was done on March 20, 1944. Esophagoscopy with Levine tube passage was performed on March 16, 1944. The operation after esophagoscopy was done with Levine tube passage. At this time the patient was receiving intravenous feedings. He could tolerate nothing by mouth.

The patient was kept on sulfadiazine because of fear of infection of the pleura and mediastinum after opening of the esophagus. The temperature went up postoperatively, going up and down in what appeared to be due to either inadequate drainage or absorption of blood or foreign protein. On the sixth day it went up to 104.8°F. with respirations 34, pulse 120, and the patient looked toxic (March 25, 1944). On March 24th the Levine tube was pulled out by the patient. It was reinserted and *x*-ray showed correct position. On the following day the tube was removed and his temperature, pulse and respirations went up five hours later. On March 26th a chest tap was done and 50 cc. of serosanguineous fluid, high protein, was obtained. The patient improved with oxygen and supportive care.

The chest findings were always the same. There were no signs of atelectasis, fluid increase, shift in trachea, etc. On March 28, 1944, the patient still had a low grade temperature, but the wound which was infected down to the fascia was considered part of the factor. Tyrothricin was used for irrigating and wet dressings, $\frac{1}{10}$th dilution. The Levine tube was removed while the patient swallowed ice and mineral oil.

On April 17th, physical findings suggested fluid in the left base as did *x*-ray findings (tuberculosis *x*-rays showed resorption fluid). The patient was fluoroscoped for determination of fluid. A tap was done and 250 cc. of thick, serosanguineous fluid was obtained. On April 20th the temperature, pulse and respirations were normal. There was slight post-prandial pain, some colicky component, but no obstructive signs or symptoms. The patient was ambulatory. Tincture of belladonna and mineral oil, and a gastrointestinal series was ordered. On May 15th, fluoroscopy demonstrated that anastomosis was good, the cap was working well and the patient was discharged.

Case IV. L. L. was a fifty-three year old male with a history of pneumonia followed by chronic empyema. He then had bloody urination and had the left kidney removed for diagnosis of a tuberculous kidney. The patient had left-sided empyema again which betrayed itself with a septic temperature.

Physical examination revealed a robust, slightly obese white male, slightly dyspneic. The trachea was in the midline. The apex beat of the heart was at the fifth interspace, midclavicular line. The cardiac outline and size were normal to percussion and auscultation. There was slightly increased resonance and slightly increased breath sounds with emphysematous tinge. There were dullness and diminished breath sounds on the right side of the pulmonary field anteriorly and posteriorly below the fourth interspace. Above this area there was slightly increased breath sounds with a little more resonance. There was the mark of an incision in the left loin with slight herniation (site of nephrectomy, 1942). No liver, spleen or other masses were palpable, and the extremities showed no clubbing or cyanosis.

Operative procedures designed at obliteration of the chronic empyema cavity by collapse of the chest wall through removal of ribs above were then done. The series of operations were done on January 10, 1944, January 27, 1944, February 26, 1944 and March 27, 1944. The removal of from the third to the eighth ribs inclusive, over the cavity reduced it to a narrow sinus tract which now held about 60 to 80 cc. in contrast to the original 400 to 500 cc. capacity of the original empyema cavity size.

However, the patient developed signs of liver damage with jaundice and a rather severe anemia. Associated with this clinical depression the patient's morale became too poor to have further operative procedures at this time. He was, therefore, sent home to convalesce and to return when improved. A thoracotomy tube

was left in place in the sinus tract and irrigations desisted because of an air embolism episode just before discharge which fortunately left no sequalae.

CASE V. L. McK. was a forty-six year old white female with a one and a half year history of tuberculosis, right side, with ineffectual pneumothorax treatments. There was no hemoptysis, but positive sputum obtains. Thoracoplasty operations were decided upon for right side lung treatment.

Physical examination revealed a well nourished, slightly obese female, ambulatory, non-dyspneic, non-febrile and not cyanotic. The apex beat was heard at the fifth interspace, mid-clavicular line; there were no murmurs. There were diminished breath sounds below the ninth interspace on the right side and diminished sounds throughout the rest of the lung with slight increase in resonance. The left lung was normal. No liver, spleen or masses were palpable, and the extremities showed no clubbing, cyanosis or edema.

Impression: Tuberculosis, right side, with partial pneumothorax.

*X*-ray findings showed tuberculosis of right lung with partial re-expansion and with partial pneumothorax.

CASE VI. L. J. was a twenty-five year old colored female with a history of cold and continual cough with temperature in February, 1944. There was no hemoptysis. She was admitted to Harlem Hospital on March 13, 1944, where diagnosis, *x*-rays and positive sputum of tuberculosis obtained. She was admitted to this hospital, Tuberculosis Pavilion on April 6, 1944, and to Thoracic Surgery service on May 19, 1944, with bilateral tuberculous cavitation of the left lung.

Physical examination revealed a semi-ambulatory patient, slightly dyspneic, not cyanotic and febrile. The trachea was very slightly deviated to the left side but there was no cervical adenopathy. The heart was normal in outline and shape. There were no murmurs and the apex beat was heard at the fifth interspace, mid-clavicular line. On the right side there was a normal percussion not bute numerous crackling crepitant râles were heard throughout the chest anteriorly and posteriorly. The left chest had slightly increased resonance with bronchovesicular breathing over the anterior aspect from the first to the fourth interspace. The rest of the chest had slightly impaired resonance with patches of bronchovesicular alternating with normal breath sounds. Fine crepitant râles were heard throughout the chest. No masses, liver or spleen were palpable, and there were no clubbing, cyanosis or edema of the extremities.

Impression: Bilateral tuberculosis with extensive cavitation on the left side, including a giant cavity in the left apex located anteriorly about 10 cm. in diameter.

The Monaldie operation was done for a giant cavity on the left side, May 25, 1944.

CASE VII. S. C. was a twenty-five year old female with a history of pulmonary tuberculosis of six years' duration. The diagnosis by a private physician was confirmed at Otisville, and then at Bellevue where a thoracoplasty was advised until spread in the right lung presented. The patient came here and after plenographic studies, was advised to have a three-stage thoracoplasty for left apical cavity.

Physical examination revealed a well nourished ambulatory female, afebrile, in good condition without any signs of dyspnea, cyanosis or anemia. The apex beat was heard at the fifth interspace, mid-clavicular line. The cardiac outline was normal in size and shape. On the right side there were essentially normal resonance and breath sounds. On the left side there were dullness and increased breath sounds over the left apex posteriorly with soft crepitant râles over the same area.

Impression: Pulmonary tuberculosis of the left lung with cavitation.

A first stage thoracoplasty was performed on June 1, 1944, followed by an uneventful convalescence.

CASE VIII. E. McG. was a thirty-eight year old white male with a history of tuberculosis of the right upper lung of about one year's duration. The patient had had no night sweats, hemoptysis, or loss of weight. Cough and continual fatigue obtained though, which led to the above diagnosis. In May, 1944, the patient "caught a cold" and tuberculosis spread with cavitation of the right upper lobe and an increasingly positive sputum. Careful consideration of his case argued for immediate institution of thoracoplasty operations for collapse of the right lung rather than institution of pneumothorax treatments. This decision was influenced not only by the extent of the cavitation but also by the presence of

emphysematous blebs which might be ruptured by air installation into the pleural cavity.

Physical examination revealed a well nourished ambulatory, somewhat attenuated male, not dyspneic, febrile, or cyanotic. The trachea was slightly deviated to the right. The apex beat was heard at the fifth interspace; there were no murmurs. In the right upper lobe numerous râles were heard throughout the apex anteriorly and posteriorly. There were occasional patches of bronchovesicular breathing posteriorly. The rest of the lung, and left side were relatively normal. No liver, spleen or masses were palpable, and there were no clubbing, cyanosis or edema of the extremities.

Impression: Tuberculosis of the right lung, especially right upper lobe with cavitation.

*X*-ray studies showed tuberculosis of the right upper lobe with cavitation in the apex and emphysematous blebs. The left lung was relatively normal.

Case ix. M. K. was a thirty-seven year old white male with a history of one and a half years' duration of left-sided pulmonary tuberculosis. Initial pneumothorax treatments were followed by pleural effusion and then mixed empyema. Repeated aspiration did not allow for adequate drainage and the patient was admitted for closed thoracotomy. This was done and a first stage thoracoplasty for reduction of the empyema cavity then planned.

Physical examination revealed the patient to be only semi-ambulatory, markedly dyspneic, but with little cyanosis. Low grade febrile temperature persisted. The trachea was deviated to the left. No murmurs were heard and the apex beat was elicited at the sixth interspace, mid-clavicular line. No liver, spleen or masses were palpable, and there were no clubbing, cyanosis or edema of the extremities.

Impression: Right-sided pulmonary tuberculosis with mixed empyema and closed thoracotomy drainage of same.

*X*-ray studies showed infiltration of the right lung apex with fluid filling the lower two-thirds of the thorax and the tube *in situ* in the sixth interspace. A first stage thoracoplasty on the right side was performed on July 13, 1944.

Case x. M. V. gave a history of cancer for one year of the left breast with radical mastectomy. Concomitantly the patient was discovered to have tuberculosis of the right apex with cavitation. Pneumothorax treatment and Jacobaeus operation were attempted ineffectually. The patient was admitted to the Tuberculosis Pavilion early in April and from there transferred to Thoracic Surgery on April 14, 1944, for thoracoplasty operations of the chest.

Physical examination revealed a fifty-four year old white female, robust, with florid complexion, ambulatory, not febrile, dyspneic, cyanotic or edematous. The trachea was in the midline. Shape and outline of the heart were apparently normal. On the right side, dullness posteriorly and bronchial breath sounds in the apical region were heard. There was dullness with diminishing breath sounds in the right base. The left side was normal to percussion and auscultation. A radical mastectomy scar on the left side, site of operation performed in 1943, was visible. On the right upper quadrant, a scar from cholecystectomy (1934) was seen. The liver was palpable one finger down but not tender. No masses or spleen were palpable, and there were no clubbing, cyanosis or edema, of the extremities.

Impression: Tuberculosis of right apex, with probable cavitation and pleural thickening of the right lung.

A three-stage thoracoplasty on right side was done, taking out the first eight ribs. An uneventful recovery followed; sputum was negative and *x*-ray showed the chest wall collapsed and obliteration of the cavitation in the lung field.

Case xi. W. S. was a thirty year old colored male with a history of left pulmonary tuberculosis of two years' duration. The patient was admitted for left-sided thoracoplasty. (He gave a history of upset stomach with powders after meals, and kidney trouble on the left side.)

Physical examination revealed a robust colored male, ambulatory, non-febrile. The trachea was in the midline. There were no murmurs and the apex beat was heard at the fifth interspace. There were diminished breath sounds in the left chest posteriorly, mostly in the region of the scapular area and occasional râles and coughing over the apex. The right side was essentially normal. No liver, spleen or masses were palpable. There were no clubbing or cyanosis of the extremities. The right hand was atrophied with partial amputation of fingers due to a bullet wound many years previously.

Impression: Pulmonary tuberculosis on the right side.

*X*-ray findings confirmed the above impression and demonstrated a good right lung. A first stage thoracoplasty was performed on August 17, 1944.

Case xii. J. G., a thirty-six year old white male gave a history of pulmonary tuberculosis on the left side of eighteen years' duration. Pneumothorax was initiated and was determined as ineffectual. Continued aspiration of effusion was done until 1935. A bronchopleural fistula was determined at this time by positive *x*-rays and gentian violet expectoration. A three-stage thoracoplasty in 1937 and 1938 was done. Then a thoracotomy for empyema was performed and the patient sent home with the tube in. In January, 1944, the patient developed a chest wall abscess below the thoracotomy tube. The abscess was incised and drained at that time. He was admitted to chest surgery at the Metropolitan Hospital, on May 22, 1944, with a diagnosis of osteomyelitis of the left chest wall and tuberculosis of the lung.

Physical examination revealed a thin, but well nourished male, ambulatory, and in no acute distress. The trachea was in the midline. The heart was regular in outline and normal in size. There were no murmurs. In the chest wall there was a thoracotomy tube at about the sixth interspace, anterior axillary line, draining yellowish, creamy pus. Another small tube through the sinus tract was superficially located under the skin also in the anterior axillary line but in the tenth interspace. (Site of osteomyelitis of the ribs.) The right side of the chest wall was essentially normal. On the left side, there were diminished breath sounds from about the fifth interspace downward anteriorly and posteriorly. Emphysematous breath sounds were heard above this area with increased resonance to percussion. In right lung fields there were increased resonance and slightly increased emphysematous breath sounds. No hepar, spleen or masses were palpable, and no clubbing or cyanosis was visible in the extremities.

Impression: Tuberculosis of left lung with mixed empyema and osteomyelitis of the seventh, eighth, and ninth ribs anteriorly.

A plastic revision of the chest wall with removal of osteomyelitic seventh, eighth, and ninth ribs anteriorly was carried out on May 25, 1944.

Case xiii. H. S. was a sixty year old white male with a history of pneumonia on the right side. He developed a most massive empyema which was drained by a closed thoracotomy. The patient became incontinent and irrational, and pulled the tube out which was replaced.

Physical examination revealed a febrile, critically ill, aged white male with extremely massive empyema which displaced the trachea and mediastinum excessively to the contralateral side. Examination of the chest revealed occasional extra-systoles and poor heart sounds. The apex beat was at the sixth interspace, almost anterior axillary line, on the left side. The hepar was about two fingers down. Two plus edema of the legs was present.

Impression: Massive postpneumonic empyema with anasarca due to hypoproteinemia.

The patient expired after reinstallation of the thoracotomy tube, and before adequate high protein replacement by debilitated vitiated tissues could be achieved.

Case xiv. C. R. was a three one-half year old Filipino female with a history of pneumonic process in the left chest, particularly of the upper lobe. Moot etiology of ingestion of oily nose drops was obtained from the mother. The probability of a lipoid pneumonia by aspiration was considered, particularly since the bizarre *x*-ray picture suggested an atypical pneumonitis with probable cystic lung background. An empyema of an interlobar nature followed on this left side. Repeated chest aspirations and replacement in a like quantity with penicillin plus intramuscular injections of penicillin was done unsuccessfully. A closed thoracotomy in the eighth interspace anteriorly, axillary line, was done on July 29, 1944. After a few days the drainage material became thick and inspissated. An open thoracotomy was then done on August 28, 1944. Removal of 2½ inches of the eighth and ninth ribs in the anterior axillary region was then done to increase drainage. Packings with crude penicillin have been inserted to date.

Physical findings on admission showed the patient to have a low grade fever and to be slightly cyanotic. All findings were essentially negative except for slight dullness and bronchovesicular breathing over the left lower chest posteriorly below the scapula.

Physical findings after operation were as follows: Temperature, pulse and respirations normal; no cyanosis or dyspnea present.

There was a small sinus in the eighth interspace, anterior axillary line, on the left side, draining a very small amount of thick pus with Staphylococcus aureus the predominant organism. The cicatrix around the sinus was healing slowly but well. Breath sounds were still bronchovesicular, but over the area which was drained dullness still persisted. *X*-ray findings suggested a lung abscess at the base of the left lower lobe and the rib resection with resultant pneumonitis and very small residual empyema present. The rest of the left lung still showed cyanotic mottling. The right lung was essentially normal.

Case xv. S. R. was a thirty-seven year old colored female with a twelve year history of bilateral pulmonary tuberculosis. Bilateral pneumothorax treatments were instituted, the right side in 1934 and the left side in 1939. Despite left-sided treatments large cavitation of the left apex of the lung developed with persistent high tubercle bacilli in the sputum. Increasing sepsis in the form of continued temperature and finally hoarseness due to tuberculous invasion of the larynx occurred. Since a right Jacobaeus had been done in 1938 and a left Jacobaeus in 1940, with this bilateral problem a cavernostomy on the left side for this apical cavity was advised and the patient was admitted for same.

On admission the patient was only semi-ambulatory, dyspneic on very slight exertion, running a temperature of about 101 to 102°F. with hoarseness. There was slight cervical adenopathy on both sides; the trachea was deviated moderately to the right side. Larynx and vocal cords, examined by direct laryngoscopic study, revealed grayish exudate in tubercles on the mucous membrane. The systolic murmur over the precordium in a diffuse nature. $A^2 = P^2$. There was diminished expansion over both lung fields with emphysematous breath sounds at both bases. Bronchial breathing was heard over the left lung posteriorly between the fifth and eighth spaces along the vertebral border of the scapula. There were no masses, liver or spleen palpable. There was slight clubbing of the extremities but no cyanosis or edema.

Impression: (1) Bilateral pulmonary tuberculosis with bilateral pneumothorax; (2) cavitation of the left apex located posteriorly between the fifth and eighth ribs.

*X*-ray studies showed bilateral advanced tuberculosis of caseous pneumonic type with bilateral pneumothorax and a giant cavity involving the larger portion of left upper lobe of the lung posteriorly.

Cavernostomy at the sixth interspace on the left side about 4 cm. from vertebral column posteriorly was carried out on October 16, 1944. The patient developed increased dyspnea with slight effusion postoperatively about ten days. She then made a slow but steady recovery to date.

PROTEIN CONTENT, PLEURAL EFFUSIONS AND EMPYEMA

| Condition | Proteins, Per Cent |
|---|---|
| 1. Esophagogastrostomy (for megaloesophagus) postoperative | 7 |
| 2. Lobectomy (postoperative) | 4 |
| 3. Pneumococcic empyema | 3.6 to 5 |
| 4. TB mixed empyema | 5 Average |
| 5. TB effusions after Jacobaeus operations | 4 to 10 Average |
| 6. Pleural effusion with cardiac decompensation | 4 to 6 |
| 7. Fluid from pericardiotomy | 0.8 |

These statistics include values from the fifteen cases listed in this article and a compilation of chemical values obtained in chest aspirations from the male and female medical wards of Metropolitan Hospital. Thirty-one chest values are used as a basis for the above figures. All other chest aspirations which were contaminated or had the admixture of blood due to trauma were discarded.

The estimation of protein was done quantitatively by a method of precipitation with sulfosalicylic acid and reading the photoelectric calorimeter.

The gross appearance of pleural fluid insofar as apparent viscosity and its rapid adhesive and clotting effect is not always a direct function of the total protein value obtained. A more accurate coefficient is the amount and type of fibrinogen in the fluid relative to the total protein. Since the efficacy of drainage depends all too frequently upon free flow of fluid without clogging of the thoracotomy tube, this latter effect is now being investigated and will be reported in the next article on this subject.

## CONCLUSIONS

1. Hypoproteinemia in patients with intrathoracic disease is insidious in onset and course, progressive in character, and severe in its dire implication.

2. The lowering of the plasma protein is largely consequent upon the amount and type of intrapleural formation. (Percentages of protein varying from 4 to 7 per cent.)

3. Alteration of protein balance is moderated by the extent, type, and severity of operation manipulation procedure on pulmonary tissue.

4. Anticipation of large postoperative protein depletion and rapid restoral by the intravenous route (amino acids, whole blood plasma) fortified by oral ingestion is suggested as routinely as postoperative oxygen.

5. The amount of protein replacement may be calculated by the positive loss (total protein preoperatively minus postoperative blood protein and multiplying the difference by 5,000) plus the twenty-four-hour amount of fluid in the chest times per cent protein per cc. Each time the total protein value is taken its relative verity must be checked for anhydremia by red blood count or value.

## SUMMARY

1. A preliminary investigation into the value, extent, and correction of hypoproteinemia in thoracic surgery is here presented.

2. The cases in this article, some fifteen in number, have been deliberately selected as they occurred in our regular ward service without any attempt carefully to pick or color desired statistics or results. It may be added at this point that every one of our cases has come from other institutions where previous corrective attempts were either ineffectual or only partially successful. Thus all of our cases represent very good test cases for the bad risk, the poorly prepared patient, and finally those on whom all too frequently the imminence of fatality vies with the necessity for exposing that patient to operative correction.

3. It is our intention to emphasize the necessity for the use of parenteral protein intake along with the importance of recognition of protein loss in internal accumulation of pleural fluids.

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Anemia is a common feature of toxemia of pregnancy. If anemia is present to any degree, blood transfusion is indicated prior to any type of operative intervention.

From "The Management of Obstetric Difficulties" by Paul Titus (C. V. Mosby Company).

# THE USE OF FREE OMENTAL GRAFTS IN THE THORAX*

## AN EXPERIMENTAL STUDY

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THE use of free omental grafts in abdominal surgery dates back to the time of Nicholas Senn in 1887.[1] Since that time free omental grafts have been used in several areas of the body other than the abdomen.[2] We have not found, however, any report in the literature on the use of free omental grafts in the thorax.

It is the purpose of this report to give the results of animal experiments in which free omental grafts were used in the thorax, and to describe the manner in which the experiments were performed. The general scope of this work was to determine the fate of the free omental graft in the thorax, and also to determine its value and possible uses.

Dogs were used exclusively. There were 116 experiments performed upon sixty dogs. Some of the dogs died of various causes. Because of many handicaps all of the animals that died were not autopsied; however, only those experiments are reported herein which were performed upon animals which were subsequently autopsied or re-operated.

### TECHNICAL PROCEDURE

The dogs were anesthesized with nembutal (veterinary) given intraperitoneally. The abdomen and one side of the chest were then shaved. An endotracheal tube with occlusion cuff was inserted into the trachea to provide a method of pulmonary ventilation as well as a means of re-expanding the collapsed lung at the end of the operation. A small paramedian incision was made in the abdomen to obtain the omental graft. The distal edge of the greater omentum was used and a v-shaped graft was excised. No attempt was made to protect or roll in the cut edge of the donor surface. After obtaining the graft it was placed upon a wet gauze pad for immediate use or in a sterile saline or sterile Ringer's solution and stored in the icebox for future use.

The abdominal incision was closed and a thoracic incision was made in the sixth or seventh intercostal space and the thorax opened widely. Because of the thin and sometimes imperfect mediastinal partition in dogs, both lungs may collapse upon opening the chest and it is necessary to provide artificial pulmonary ventilation. This was done by the rhythmic compression and relaxation of an anesthetic bag filled with oxygen. One end of the bag was attached to the endotracheal tube. A blow-off valve prevented the accumulation of carbon dioxide.

The free omental graft just obtained or previously obtained from another dog and preserved was applied to the desired site and held in place by silk sutures or by plasma glue. The thoracic incision was closed after the lung was completely inflated. The animals were re-operated upon or autopsied at intervals of twenty-four hours to twelve weeks.

### FATE OF THE FREE OMENTAL GRAFT IN THE THORAX

Because of the pliability the graft readily lends itself to close apposition to

* From the Surgical Research Laboratory of the New York Medical College, The Flower and Fifth Avenue Hospitals. Aided by a grant from the Committee on Scientific Research of the American Medical Association.

any contour or surface; and if held lightly in place for a few minutes, it tends to adhere to the surface of the structure. At the end of twenty-four hours the graft is attached lightly and has a whitish rather than pink color. At the end of forty-eight hours the graft is definitely adherent and the fatty tissue in the graft has a whitish color. When the graft is separated, there is a granular surface at the site of attachment. At the end of seventy-two hours the graft is more firmly adherent and capillary oozing occurs upon separation of the graft.

At the end of one week the graft is firmly adherent and can be separated with difficulty. There has been some absorption of the fatty tissue in the graft which now appears to be smaller in size and has a grey-pink color. At the end of three weeks the graft is firmly adherent and cannot always be separated. Bleeding occurs freely upon separation. The fatty tissue in the graft is largely absorbed and the graft has taken on an appearance similar to the surface of its host. At the end of twelve weeks the graft can be seen with difficulty and occasionally can be identified only by its silk suture attachments. The fatty tissue has been completely absorbed. The graft is thin and almost identical in appearance to the surface of its host.

Failure of the graft to adhere and become viable (take) occurred four times in eighty-seven experiments (5 per cent). In three of the four failures the cause was attributed to infection. However, the presence of infection in more than four other experiments did not prevent the take of the graft. Two of the unsuccessful grafts were anchored with sutures and two were anchored by means of plasma glue. Three of the failures were autogenous grafts and one was homologous.

### FREE OMENTAL GRAFTS ON THE PLEURA

The graft was anchored to the visceral as well as the parietal pleura, over the inner chest wall and the diaphragmatic surface. At times the pleura was roughened by scraping with gauze before the graft was applied and at other times no scarification was done. In this series of thirty-five grafts upon the pleura there were four failures of the graft to become viable.

Microscopic study shows a thin zone of fibrin and hemorrhage between the adipose tissue of the graft and the pleural surfaces. The pleural endothelium is not seen. The subendothelial connective tissues are swollen and hemorrhagic. Throughout the adipose tissues of the graft there are small foci of fat necrosis. Red blood cells are seen in many of the vessels of the adipose tissues.

### FREE OMENTAL GRAFTS ON THE CUT SURFACE OF THE LUNG

The lung was scarified and cut with the scapel. The incisions were perpendicular and tangenital to the lung surface for a depth of 1/32 to 1/4 of an inch. This produced bleeding and multiple alveolar lacerations. The free omental graft was applied and held in place by means of silk sutures placed at the edges of the graft. Bleeding was completely controlled and no bronchopleural fistulas developed. There were no failures of the graft to become viable in ten experiments.

Microscopic study shows focal fibrinous and hemorrhagic reactions between alveolar and adipose tissues of the graft. Also slight focal fibrosis was noted. Alveolar tissues collapsed and were hemorrhagic. In the regions of the small bronchioles and terminal bronchioles there is a moderate fibrinous and polynuclear cell inflammatory reaction.

### FREE OMENTAL GRAFTS ON THE CUT EDGE OF THE LUNG

A presenting lobe was amputated approximately at its distal third. There was no preliminary clamping of lung tissue or blood vessels to control hemorrhage. This partial amputation of the lobe produced many bleeding vessels some of which were pumping in character. Also many bronchae and alveolae were opened.

The graft was applied to this raw and bleeding surface and held lightly, with only enought pressure to keep the graft from being dislodged by the pressure from the bleeding vessels. The graft is extremely pliable and adaptable and fits snugly into small crevices and across the opening of the small bronchae, blood vessels and alveolae. The graft was held in place for varying periods of no more than three minutes. At the end of this time the graft was molded to the contour of the cut edge of the lobe and all bleeding was completely stopped. It is an amazing sight to see a pumping vessel on the cut surface of the lung completely controlled by the light application of an omental graft. The use of an omental graft on the lung for hemostatic purposes has not been mentioned previously. The graft was anchored by interrupted black silk sutures around its edge only. No attempt was made to use hemostatic sutures. The grafts remained in place and became viable. There was no secondary bleeding and no bronchopleural fistulas developed in four experiments.

Table 1
FREE OMENTAL GRAFTS

| Site | No. | Failures | Per Cent* |
|---|---|---|---|
| Pleura | 35 | 4 | 11 |
| Cut surface of lung | 5 | 0 | 0 |
| Cut edge of lung | 5 | 0 | 0 |
| Stump of bronchus | 10 | 0 | 0 |
| Esophagus | 14 | 0 | 0 |
| Vena cava | 3 | 0 | 0 |
| Aorta | 3 | 0 | 0 |
| Cut lung for hemostasis | 12 | 0 | 0 |
| Total number | 87 | 4 | 5 |
| Number of autogenous grafts | 70 | 3 | 4 |
| Number of homologous grafts | 17 | 1 | 6 |

* Percentages approximate.

### FREE OMENTAL GRAFTS ON THE BRONCHIAL STUMP

A lobe bronchus or the main bronchus was isolated. The branches of the pulmonary artery and veins were ligated separately. The bronchus was clamped and cut across, thus performing a lobectomy or pneumonectomy. The bronchial stump was closed by a single surrounding ligature of silk or was closed by mattress sutures which brought the posterior surface into contact with the anterior surface. A free omental graft was placed over the stump of the closed bronchus, very much in the manner of a cap and held in place by silk sutures. The graft was definitely a factor in the prevention of bronchial fistulas since some of the bronchial stumps were closed so loosely that they were not completely airtight before the graft was put in place. There were no bronchial fistulas and no graft failed to take in ten experiments.

### FREE OMENTAL GRAFTS ON THE ESOPHAGUS

The esophagus was exposed by a left thoracic approach and free omental grafts were placed around the esophagus without any anchoring in some experiments and in others the graft was anchored with silk sutures. In some experiments the esophagus was freed and cut across in its lower one-third. Approximately one-half inch of the esophagus was excised. The cut edges were then approximated and the esophagus was united by an end-to-end anastomosis. The suture line was reinforced by wrapping a free omental graft around the esophagus at the site of the anastomosis and anchoring it with silk sutures. These dogs were allowed fluid by mouth freely at the end of twelve hours after the operation and soft food was allowed on the second postoperative day.

The grafts which were applied to the muscular coat of the intact esophagus became viable whether anchored by suture or not. There were no failures in nine experiments. Marked fibrinous reaction was seen on microscopic study between adipose tissues of the graft and adventitia of esophagus. Focal fibrosis between omental and connective tissues of the esophagus was also noted. In addition one slide shows small foci of granulation tissue between the adipose tissues and the adventitia of the esophagus.

The graft used to reinforce the suture line of the end-to-end anastomosis of the esophagus became adherent and viable and was a definite factor in the success of the anastomosis by preventing leakage. We believe that this is an important observation since the end-to-end esophageal anastomosis is a notorious failure due to leakage at the suture line with secondary infection. There were no failures of the graft to take; however, leakage at the suture line did occur once in five experiments.*

### FREE OMENTAL GRAFTS ON THE AORTA AND VENA CAVA

The descending aorta was exposed by a transthoracic approach. The overlying pleura was incised and approximately one or two inches of the anterior and lateral surfaces of the aorta was exposed. A free omental graft was then applied to the vessel and held in place by suturing to the surrounding structures. The graft became adherent and viable.

The inferior vena cava was exposed and stripped of its pleural covering. A free omental graft was applied to the vessel and held in place by sutures to the surrounding structures. The graft became adherent and viable. There were no failures of the graft to take in three experiments upon the aorta and three upon the inferior vena cava.

### AUTOGENOUS, HOMOLOGOUS AND PRESERVED GRAFTS

We were unable to note any particular difference between the action of autogenous and homologous grafts insofar as hemostatic effect and viability were concerned. Of the four failures of the graft to become viable three of these were autogenous and only one was homologous. This series is too small for definite conclusions, although we believe that homologous grafts take as well as autogenous. Eight of the grafts were preserved in sterile saline or Ringer's solution and stored in the icebox. Four grafts were preserved for twenty-four hours. Two were preserved for one week and two for two weeks. All preserved grafts were homologous and all were successful takes. We were unable to note any particular difference between the hemostatic action and viability of the immediate graft and the preserved graft.

* We are indebted to Dr. Frank D. Speer for his co-operation and assistance in the preparation and report of the microscopic slides.

### COMMENT

These experiments show that free omental grafts, when applied to such thoracic structures as the pleura, the cut surface and edge of the lung, the bronchus, the esophagus, the aorta and vena cava, will become adherent and viable in a large percentage (95 per cent). Four of the grafts in this series of experiments failed to take. Three of the graft failures were autogenous (4 per cent) and one was homologous (6 per cent). In two of the failures the graft was anchored to the surface of the lung by a plasma glue, which perhaps is not a fair method of determining viability because of the constant movement of the lung. Three failures occurred in the presence of infection; however, infection was present in six other experiments in which the graft did become viable. Therefore, in the presence of infection the graft became viable in 60 per cent.

The possible uses of free omental grafts in the thorax are: hemostatic effect, reinforcement of suture lines, and replacement of defects.

The hemostatic effect of the free omental graft has been known for some time. In 1906, Lowe[3] reported controlling hemorrhage of the liver with free omental grafts. The ability of an omental graft to control a spurting branch of the pulmonary artery by simple application with gentle pressure for three minutes is very dramatic. This property has definite clinical value.

The ability of a free omental graft to adhere and become viable over a suture line, thereby reinforcing and adding an extra layer of tissue, is probably the

outstanding value of the graft. The clinical application of this property in the closure of bronchial stumps and around an end-to-end anastomosis of the esophagus would seem to have great value.

It is admitted that the one great disadvantage of using free omental grafts in the thorax is the inaccessibility of the graft. For autogenous grafts this means opening the peritoneal cavity. Whether through the abdomen or the diaphragm, this is an added surgical procedure.

However, from our experiments on dogs it would seem that there is little difference between the action of autogenous and homologous grafts, and furthermore homologous grafts can be preserved for at least two weeks (probably longer) without affecting its viability or hemostatic effect.

The acquisition and preservation of homologous omental grafts does not present any problem in the modern hospital. In these days of blood banks, skin banks, and eye banks, the establishment of an omental bank does not need to stretch the imagination.

## CONCLUSIONS

A series of animal experiments were performed to determine the fate of free omental grafts in the thorax and their possible value.

The free omental graft readily becomes adherent to the surface of such structures as the pleura, the cut surface and cut edge of the lung, the cut end of a bronchus, the aorta and vena cava. It becomes viable and takes in a very large percentage.

The free omental graft can be used to cover defects, to reinforce suture lines, and produce hemostasis. It is particularly useful to stop hemorrhage from the lung, to cover a bronchial stump and prevent the development of a bronchial fistula, to reinforce and prevent leakage from the suture line of an end-to-end anastomosis of the esophagus.

There appears to be no clinical difference between the action of autogenous and homologous free omental grafts in the thorax, and the homologous graft can be preserved for at least two weeks (probably longer) without impairing its usefulness.

The securing of an autogenous omental graft means opening the peritoneal cavity, but in the modern hospital securing homologous omental grafts is easily accomplished from any clean abdominal operation.

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# CONSTANT TRACTION DRESSING*

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THE tendency of traumatic wounds to gape is due rather to the elasticity of the tissues pulling the wound open than to actual loss of tissue. During the time which elapses while such a wound is being prepared for secondary closure, the tissues, particularly the skin, become partially fixed in the gaping position so that when the wound is ready for closure, approximation may be difficult. In treating gunshot wounds during the early phase of the Solomons' campaign, one of us was impressed by the desirability of a dressing which would maintain gentle and continuous traction on the skin edges and which at the same time would prevent gauze from coming in contact with the raw surface. At that time attempts were made to accomplish these objectives by stretching a sheet of perforated rubber dam across the wound and fastening it with adhesive tape applied to the skin margins.

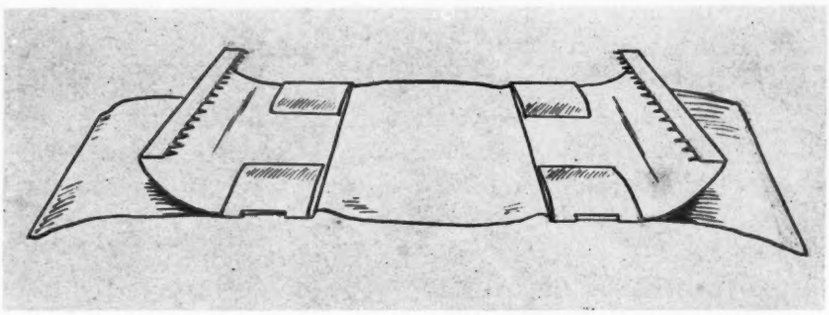


FIG. 1. Showing undersurface of the dressing. In applying it the trailing edges of fabric are grasped, the dressing is stretched, and the spurs engaged in the skin close to the opposing wound margins.

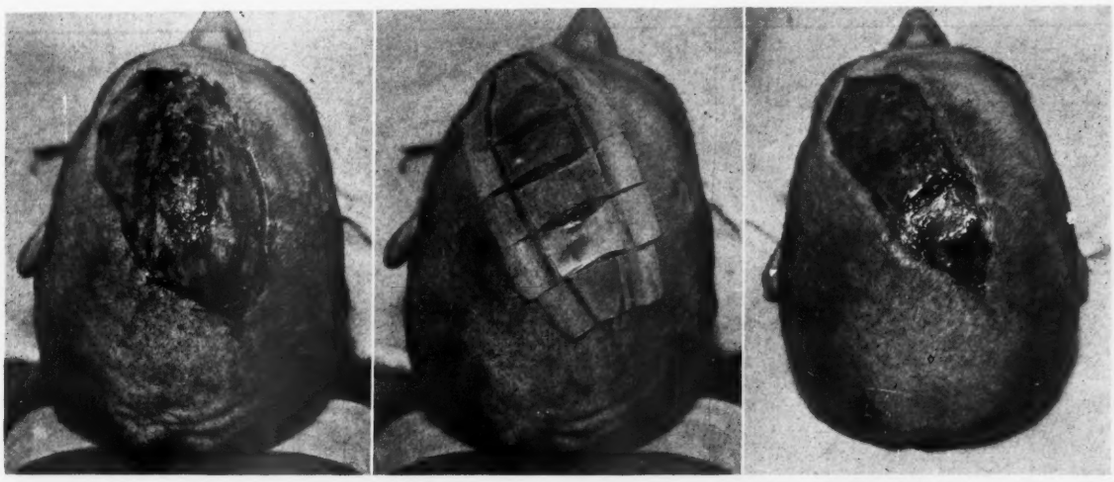
This type of dressing had the following advantages: (1) The dressing was more comfortable than the usual gauze dressing. (2) The change of dressing was atraumatic and painless. (3) When the raw surface of the wound was thus protected from irritating contact with the overlying gauze dressing, discharge was materially lessened. (4) The skin edges underwent a progressive approximation, yielding a narrower scar and in some cases avoiding the necessity of secondary suture and skin grafting.

The chief disadvantage of this dressing was that it was difficult to maintain in position because the traction of the rubber dam caused the anchoring adhesive to slide upon the skin.

Our efforts have since been directed toward devising some substitute for surgical adhesive tape which would not slide on the skin under the stress of continuous traction. The dressing shown in the accompanying illustrations was finally evolved. It consists of two metal members connected by a sheet of latex. The metal

* The opinions and assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

members are fabricated from a sheet of stainless steel 0.004 inch thick. The spurs on the metal members are 0.02 inch in length, short enough so that they penetrate only the tough stratum corneum and do not cause pain, bleeding, or inflammatory reaction. The spurs are very sharp and are set $\frac{1}{20}$ inch apart. The single row of spurs can be attached to the skin close to the wound margin, so that there is little tendency for inversion of the skin edge. The metal members are all 1 inch wide, but the elastic portion is made in various lengths for wounds of various sizes. Shorter dressings may be applied as the approximation of the skin edges proceeds. If properly applied, the dressing will not come loose until the wound is sufficiently narrowed to release the traction which keeps the spurs buried in the stratum corneum. However, contact of the latex portion of the dressing with wound secretions for four or five days does cause some reduction in its elasticity.



A B C

Fig. 2. A, a gaping wound of the scalp after excision of traumatic arteriovenous aneurysm. B, constant traction dressings applied; C, the wound four days later.

The ability of the skin to elongate itself under the influence of continuous traction is demonstrated by the Ubangi natives, who for centuries have stretched their ear lobes and lips by hanging pendants. A constant traction dressing properly applied makes this property of the skin available to the surgeon.

# Case Reports

## BENIGN GIANT CELL XANTHOMA OF THE KNEE JOINT

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TUMORS of the synovial membrane of the joints are relatively uncommon, and of the various primary benign tumors of the knee joint xanthoma is the most common. Nevertheless comparatively few cases have been reported in the medical literature.

The first case reported in the medical literature was described by Gustav Simon[1] in 1865; since that time cases have been reported from time to time and in 1939 De Santo and Wilson in reviewing the literature reported thirty-six cases. They were of the opinion that xanthomas of the knee joint are of more frequent occurrence than the reports would indicate.

It is seldom that the diagnosis is made preoperatively. The condition is said to be more common in men than women. An associated disturbance in lipoid metabolism has been occasionally noted as evidenced by the elevated blood cholesterol. The tumor mass is usually solitary but may be multiple and is usually found attached to the synovial membrane at or near the medial meniscus. Grossly the tumor is rounded or spheroidal and is usually golden yellow orange in color, studded with darkened areas representing old or recent hemorrhage. Histologically, an area of synovial-membrane mesothelium may be found surrounding the tumor mass in which any of the following type cells may be found: foam cells, fibrocellular stroma and multinucleated giant cells. Coarse yellow or brown particles of hemosiderin are present scattered throughout the field. Recurrences of the tumor have been described and have been attributed to incomplete removal or to later development of a small undiscovered tumor. No instance of a benign giant cell xanthoma undergoing malignant transformation has ever been reported. Treatment is wide surgical extirpation. A case report with gross and microscopic features are presented.

### CASE REPORT

The patient was twenty-two years old and was admitted to the surgical service because of acute appendicitis. An appendectomy was performed and he made an uneventful recovery.

During the third week of convalescence he complained of pain and locking of the right knee joint with no history of old or recent trauma, followed two weeks later by further locking of the right knee joint in flexion. He also stated that he could feel something moving around within the knee joint. Examination failed to reveal any limitation of motion at the knee joint, swelling or local heat, nor could any measurable quadriceps atrophy be demonstrated. There was no anteroposterior or lateral instability present. A small irregular mobile palpable mass about 1 cm. in diameter could be palpated at the anteromedial aspect of the joint. The clinical impression was that of a loose body within the knee joint, probably a "joint mouse." Roentgenographic studies of the knee revealed no evidence of a loose body within the joint cavity. Blood count, urinanalysis and blood Kahn tests were reported as normal.

On the basis of a palpable mass within the joint surgical exploration was undertaken through a medial parapatellar incision. Upon opening the synovia, a small amount of yellow orange fluid escaped. A small pedunculated tumor mass 2.5 by 1.0 by 0.4 cm., attached to the synovia on the medial side of the right

knee joint just above the articulation presented itself. The mass was gray brown in color and on section revealed tissue of an orange brown color, throughout which were scattered areas of a darker brown. The tumor was resected and a wide base of normal appearing tissue was removed with the mass. The defect in the synovia was closed and the patient made an uneventful recovery. Blood cholesterol studies were done postoperatively and were reported as 207 mg. per 100 cc.

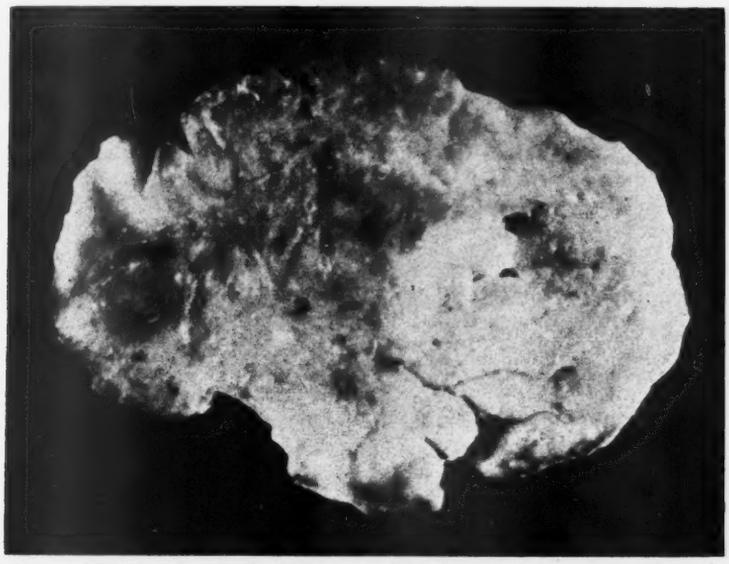

FIG. 1. Benign giant cell xanthoma of the knee joint; gross specimen.

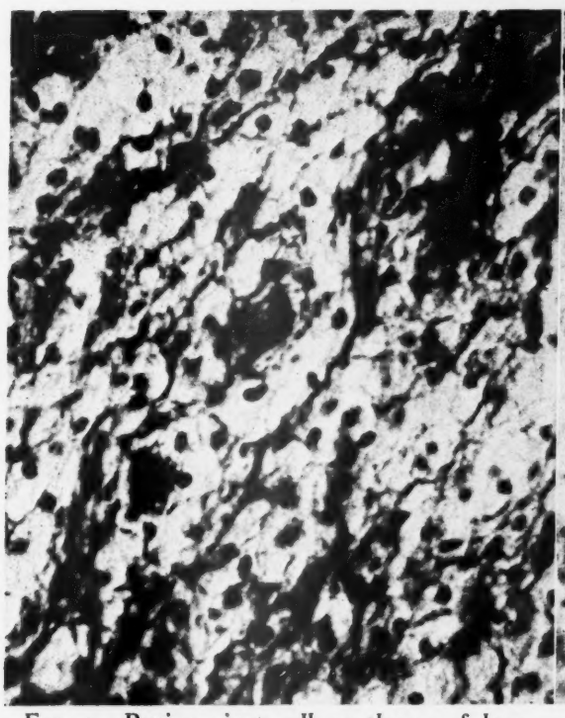

FIG. 2.—Benign giant cell xanthoma of knee joint; microscopic section.

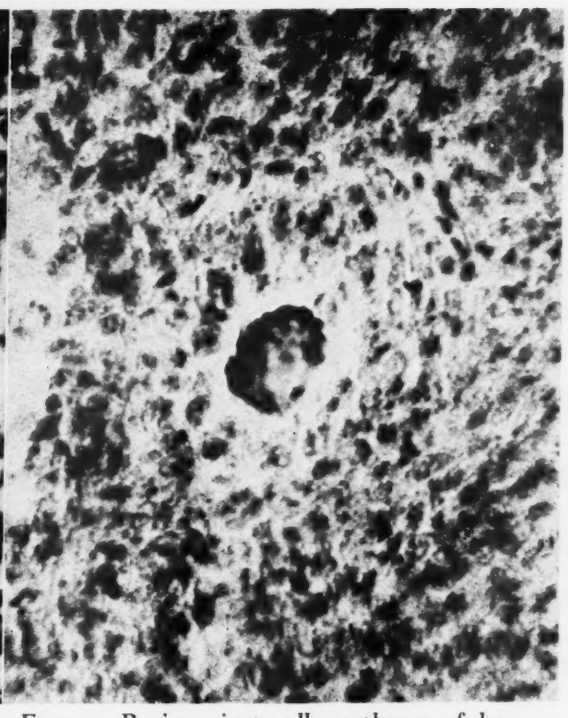

FIG. 3.—Benign giant cell xanthoma of knee joint; microscopic section.

Macroscopically (Fig. 1) the specimen consists of two masses of tissue, the larger of which has a yellow color and a shiny, white capsule. The larger mass measures 2 by 1.5 by .4 cm., and appears to be a flattened sphere with a rounded superior portion and a narrowed base. On section the stroma is composed of areas of whitish-gray, fleshy tissue mixed with other areas of yellow staining, irregular masses. No pus can be expressed from this mass. Impression: Xanthoma of knee joint.

Microscopically, (Fig. 2) the section shows cellular tissue, with fibroblasts, epulis-like giant cells, and a few dilated capillaries. Patches of hemosiderin pigment are noted, as well as sheets of large lipoid containing cells. (Fig. 3.)

Diagnosis: Giant cell tumor-xanthoma variant.

We believe this case is of interest because of the following: (1) Its relatively infrequent occurrence. (2) Three weeks elapsed between the time of the patient's first complaints referable to his right knee and the time of surgical removal. (3) *X*-rays were of little value in making the diagnosis and the fact that they were non-revealing in the presence of clinical findings should make one suspicious of a neoplasm within the knee joint.

SUMMARY

1. A case of benign giant cell xanthoma has been reported.

2. Gross and histologic features have been presented.

3. Treatment is wide surgical extirpation.

4. In no instance has malignant transformation been reported.

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# POSTOPERATIVE THROMBOSIS OF THE ILIAC VEIN*

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HONOLULU, T. H.

THE threat of postoperative and puerperal thrombophlebitis hangs constantly over the surgeon's and accoucheur's head. The following case report of postoperative thrombosis of the iliac and tributary veins is, therefore, presented and its treatment is discussed.

## CASE REPORT

Mrs. A. R., a twenty-five year old Caucasian, first came to the obstetrical department of The Clinic for prenatal care on October 5, 1943. She had had an appendectomy and a "scraping of the right ovary" seven years previously and an attack of pyelitis five years previously. Since the attack of pyelitis she had been known to have a ptotic right kidney. Intravenous pyelograms taken on August 9, 1943, showed prolapse of the right kidney with slight hydronephrosis. Her last menstrual period had begun on August 24, 1943. General physical examination was entirely normal except for evidence of pregnancy. Her blood pressure was 110/78, and urinalysis was normal.

Her pregnancy progressed uneventfully until February 29, 1944, when she returned for a periodic prenatal examination at the sixth month. She had at that time noticed puffiness of the hands and feet and had had mild headaches. There were no visual disturbances. Examination revealed an 11 pound weight gain in three weeks, marked pitting edema of the feet and ankles and edema of the hands and eyelids. The blood pressure was 140/90. Urinalysis showed 4 plus albuminuria but no acetone, acetic acid, blood or casts in the urine. The patient was admitted at noon of the same day to the hospital. Treatment consisted of bed rest; a low salt, high protein diet; ammonium chloride and magnesium sulfate orally; sedation in the form of pentobarbital orally; and 500 cc. of 20 per cent glucose intravenously. Plasma proteins were 5.3 Gm. per 100 cc. At 6:40 P.M. a plasma infusion was begun but the patient had a severe urticarial reaction about the face and chest within twenty minutes, and the infusion was stopped after less than 50 cc. had been given. At 7:30 P.M. there was a moderate urticaria of the face and chest. The patient complained of a severe headache but had no aura. She had vomited once and felt nauseated. Her temperature was 100°F.; her pulse rate was 110 per minute; and the blood pressure was 174/110. It was believed that most of the symptoms and signs were due to fulminating pre-eclampsia rather than the anaphylactic reaction, especially in that the blood pressure had risen steadily during the afternoon. Pelvic examination revealed a rigid, elongated cervix with inaccessible membranes. It was believed that interruption of the pregnancy by hysterotomy under local anesthesia was indicated in order to prevent full-blown eclampsia.

Inasmuch as the pregnancy was of only six months' duration, 3 g. of pentobarbital orally and 1/6 g. of morphine subcutaneously were given for pre-anesthetic sedation. Novocain, 1 per cent, locally, was used as the anesthetic agent. A classic cesarean section was done, and the patient delivered of a female which lived only a few minutes. Pitocin, 1 cc., was injected into the uterine musculature and 0.2 mg. of ergotrate was given intravenously after the delivery of the placenta. Blood loss was minimal.

By the next morning the patient looked much improved and her blood pressure was 140/100. She improved rapidly and was far more cooperative than the average patient in moving about the bed and in exercising her legs and feet. Sutures were removed from the wound, which healed per primum, on the seventh postoperative day. She dangled her legs over the bed on the same day and was up in a chair on the eighth day, walked on the ninth day, and was discharged home on the tenth postoperative day. During her convalescence there were no symptoms or signs of deep phlebitis of pelvic or leg veins. Her blood pressure on discharge was 138/80, and urinalysis revealed only a trace of albumin.

The patient was next seen at home on March 23, 1944, twenty-three days after the hysterot-

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omy and thirteen days after discharge from the hospital. She stated that she had been well and had been up and about the house until

FIG. 1. Photograph of patient taken one month postoperatively. Note absence of edema and venous dilatation.

three days previously (March 20th) when she began to have pain in the left calf. The pain became increasingly severe during the following three days and forced her to go to bed as walking was unbearable. She had not felt feverish at any time nor had she had any chill. Examination revealed pitting edema of the left lower leg and moderate swelling of the left thigh without heat or redness. The left calf was tender as was the course of the femoral vein up to the inguinal ligament. Dorsiflexion of the foot elicited severe pain in the calf. There was no abdominal tenderness and the abdominal wound was well healed. The temperature was 100.6°F.

Two hours later the temperature had risen to 101.6°F., but otherwise the findings had not changed. There was no tenderness above the inguinal ligament nor was there any rectal tenderness. It was believed that the patient had a thrombosis and possible phlebitis of the left femoral vein and its branches and that prompt ligation of the femoral vein proximal to the thrombosis might well prevent a fatal pulmonary embolus.

Under spinal anesthesia with 10 mg. of pontocaine a longitudinal incision was made over the junction of the left saphenous and femoral veins. Both were found completely thrombosed, the latter up to the inguinal ligament. A left supra-inguinal incision was then made and the retroperitoneal region exposed. All the deep veins of the pelvis on the left side, including the femoral, hypogastric, and external and common iliac, were completely thrombosed up to the bifurcation of the inferior vena cava. There was massive edema about these veins. The left common iliac vein was inadvertently opened and a small amount of serous whitish fluid extruded. This was cultured. The clot in this vein seemed poorly attached to the vein wall.

The left common iliac vein was then doubly ligated with No. 1 chromic catgut at its junction with the vena cava. The left sympathetic chain was located and about one inch of it, including the fourth or fifth lumbar ganglion, was removed. Six Gm. of crystalline sulfanilamide, along with two soft rubber drains, were inserted and the wound was then closed in layers with No. 0 chromic catgut.

The spinal anesthetic was supplemented with cyclopropane and oxygen inhalation anesthesia. One thousand cc. of citrated banked blood was given intravenously during and immediately following surgery. Following surgery 2.5 Gm. of sodium sufadiazine and also 20,000 Toronto units of heparin dissolved in 1,000 cc. of saline were given intravenously over a three-hour period. Wangensteen suction was instituted. The postoperative condition was fair.

On the morning of the first postoperative day the temperature was 99.6°F., the pulse 136, and the patient's general condition was improved. Clotting time was five minutes. The blood count showed 4,450,000 red cells, hemoglobin 84.6 per cent (11 Gm.), white cells 13,200, with 92 per cent polymorphonuclear leukocytes. Wangensteen suction was discontinued and a light diet was given. One Gm. of sulfadiazine and 0.6 Gm. of bicarbonate of soda were given orally every four hours. Then slow intravenous drip of 30,000 Toronto units of heparin in 1,000 cc. of normal saline was begun.

The blood clotting time at noon was over two hours. Before this had been reported, the patient had been given 300 mg. of dicumarol by mouth, but had vomited most of it shortly

afterward. At this time the wound began to discharge a large amount of bright red blood. The patient was immediately given 1,000 cc. of citrated banked blood. Five hours later the clotting time was twenty-three minutes but the prothrombin level was so low that it could not be determined. Large doses of vitamin K were given intramuscularly, and another 500 cc. of citrated banked blood was given. The patient's condition was fair despite a large amount of blood loss from the wound. There was no evidence of bleeding elsewhere. Because of vomiting sulfadiazine was given by vein instead of by mouth. The wound culture taken at operation was now reported as showing "only a few streptococci."

By the next morning, the second postoperative day, the clotting time was five minutes, the prothrombin level 73 per cent of normal, the red blood count 3,360,000, hemoglobin 66.7 per cent (8.8 Gm.), white count 12,250 with 85 per cent polymorphonuclear leukocytes. Bloody serum only was discharging from the wound, though it was evident that the patient had a large wound hematoma. The temperature was 101°F., pulse 130. The patient looked and felt well and was hungry. She was urged to swing her feet over the side of the bed and to exercise vigorously the contralateral leg, especially by plantar flexion and extension exercises.

On the morning of the third postoperative day the clotting time was five minutes but the prothrombin level had dropped to 56 per cent of normal, probably due to the delayed effect of the small amount of dicumarol she had retained two days previously. Her sulfadiazine level was 12 mg. per 100 cc. of blood. Urinalysis was normal. Oral sulfadiazine was resumed at this point in place of the intravenous. On the fourth postoperative day the clotting time was four minutes and the prothrombin level was normal.

Up to and including the sixth postoperative day, the temperature remained in the vicinity of 101°F., and on that day the red blood count was 1,830,000 hemoglobin 41.5 per cent (5.4 Gm.), white blood count 16,300 with 79 per cent polymorphonuclear leukocytes. Urinalysis was normal. It was believed that the anemia was due to sulfonamide sensitivity as there had been no recurrence of fresh bleeding from the wound or elsewhere. The wound was discharging syrupy black blood only. Accordingly, the sulfadiazine was withdrawn and a 1,000 cc. transfusion of citrated banked blood given. The following day the temperature fell to a normal level where, with slight variations, it remained for the rest of the hospital stay.

On the eleventh postoperative day the sutures were removed and the patient sat in a chair; she walked on the twelfth postoperative day. On the fifteenth postoperative day the red blood count was 3,350,000 and the hemoglobin 76 per cent (9.9 Gm.). At this time the edema of the left foot, leg and thigh which had been marked began to regress. When the patient was discharged home on the twenty-fifth postoperative day, with minimal wound drainage, she had only slight edema of the left leg and foot, and was able to walk without difficulty. She was seen at regular intervals at the office and convalescence continued uneventfully. A photograph taken on April 27, 1944, (one month postoperatively) shows practically no difference in size of the two legs. The edema had entirely disappeared. (Fig. 1.)

### COMBINED USE OF HEPARIN AND DICUMAROL

The use of anticoagulants without surgery in the prevention of venous thrombosis, extension of venous thrombosis, and pulmonary embolism has recently received considerable attention.[1,2] Statistics point to a greatly reduced incidence of initial or repeated pulmonary embolism in patients under fifty years of age treated with anticoagulants alone. Patients over fifty years of age with venous thrombosis, especially those who have had a non-fatal embolism, have responded less favorably than younger patients to the use of anticoagulants without venous section and ligation.

Heparin, a tissue extract, obstructs the conversion of prothrombin into thrombin. Diluted in normal saline or glucose solution and given slowly by vein it acts almost immediately. Dicumarol, on the other hand, has a delayed action, according to Evans,[1] from one to six days; usually its effect is present in twenty-four to seventy-two hours. The effect of both of these drugs on any patient cannot be accurately predicted, there being a wide variation in effect on different individuals. The effect of heparin is observed by repeated clotting

time determinations taken at three- or four-hour intervals until a fifteen-minute clotting time is reached. Attempt is made to maintain the clotting time at this level until the dicumarol prolongs the prothrombin time.

Heparin administration prolongs the clotting time and the clot retraction. According to Evans it may lower the prothrombin level to 75 per cent of normal. Dicumarol, now synthesized (formerly extracted from spoiled sweet clover), is a poison the exact mode of action of which is unknown. It interferes, however, with the formation of prothrombin, and thus lowers the prothrombin level. Evans states that it prolongs the clotting time only when the prothrombin level is very much reduced (in the vicinity of 40 per cent of normal) and that it has no consistent effect on clot retraction, platelet count, serum calcium or serum fibrinogen.

Dicumarol given by mouth is begun simultaneously with the heparin. Like heparin, its effect on the individual varies tremendously, so that attempts to standardize dosage have failed. Evans recommends an initial dose of 300 mg. for a patient less than 120 pounds and 400 mg. for one above that weight, followed by a daily maintenance dose of 100 to 300 mg. daily. The prothrombin level is reduced to less than 70 per cent of normal; the drug is discontinued if it should fall below 60 per cent of normal. Judgment is necessary in the administration of the daily dose; a rapidly falling prothrombin level necessitates withdrawal of medication or reduction of the dose. A slowly falling prothrombin level requires a larger daily dose.

With venous thrombosis, with or without pulmonary embolism, the dicumarol should be continued for one or two weeks. Evans believes that the patient may sit up as soon as the prothrombin level is below 70 per cent of normal. Of forty of his patients with postoperative venous thrombosis, nine were out of bed within one week and twenty-seven within two weeks. Of forty-six patients with venous thrombosis treated with dicumarol, with or without heparin, he reports only one benign and no fatal emboli.

There is some evidence[3] that the administration of large doses of vitamin K may reduce the prolonged prothrombin time created by the administration of dicumarol. Whole fresh blood transfusion and the withdrawal of the drug are the most effective measures in reducing the prolonged clotting and prothrombin time induced by either heparin or dicumarol.

Needless to say, anticoagulant drugs are no panacea. They have not supplanted prophylaxis, including specifically postoperative foot dorsiflexion and extension exercises, and avoidance of unnecessarily prolonged restriction in bed. They have not done away with the necessity for constant awareness of the spector of thrombosis in every postoperative or puerperal patient and prompt recognition and institution of treatment.

Barker, Allen, and Waugh[2] list the absolute contraindications to the use of dicumarol as follows: (1) renal insufficiency, (2) purpura of any type, (3) blood dyscrasias with bleeding tendencies, and (4) existing prothrombin deficiencies, as in jaundice, hepatic disease, malnutrition and subacute bacterial endocarditis.

They list the following as relative contraindications: (1) existence of ulcerating lesions, open wounds, or potentially bleeding surfaces, (2) necessity for surgical operation during the next two weeks, and (3) continuous gastric drainage.

The reasons for these contraindications are clear when they report forty-seven cases of bleeding, eighteen of them (4 per cent) serious, in a series of 497 postoperative cases treated with dicumarol. Evans reports two deaths (4 per cent) and eight cases of hemorrhage (14 per cent) out of fifty-six patients treated with dicumarol at The Lahey Clinic. The great variation of individual tolerance to heparin and dicumarol make their administration difficult and may result in hemorrhage as in our case. This need not be wound hemor-

rhage. There may be cerebral hemorrhage, pulmonary hemorrhage from the region of the infarct, or urinary tract bleeding; indeed, bleeding may occur almost anywhere. Small initial doses and close observation are recommended when these drugs are used. The short duration of the effects of heparin, as contrasted to the delayed and prolonged effects of dicumarol, makes it the safer drug even though it is more difficult to administer and is more expensive. Prolonged, slow intravenous drip of dilute heparin solution is probably safer therapy than the combined use of both heparin and dicumarol.

### SURGICAL INTERVENTION

Proximal venous ligation is by no means obsolete, not only in patients over fifty years of age with venous thrombosis and a warning non-fatal embolism, but also in some younger patients. Our patient had a large loosely attached clot in the iliac vein which if cast free might well have caused an initial fatal embolism without warning. Awareness that thrombophlebitis and phlebothrombosis are often associated is necessary in the proper evaluation of the patient and the proposed therapy.

Prompt femoral vein ligation in the presence of a deep venous thrombosis of the leg interposes a block to proximal propagation of that thrombus and to any emboli that may be released. If the ligation can be carried out at the junction of a large patent vein, such as the profunda femoris, no stagnant venous pool is left proximal to the ligature. This is a worthwhile precaution, if possible, for propagating thrombi proximal to the region of ligation have been reported. For this reason Evans has recommended the use of anticoagulant therapy following femoral ligation. We do not hold this usually necessary, especially as there is a high incidence of hemorrhage from the use of anticoagulants; apparently ligation of the femoral vein proximal to the thrombosis is rarely followed by pulmonary emboli. In the case presented anticoagulants were used because of the extension of the thrombus to the bifurcation of the vena cava and the risk of thrombotic extension to the contralateral iliac vein. Their use was promptly discontinued because of the above stated bleeding tendency, especially since the prothrombin level fell so low before the dicumarol could have had effect. Vitamin K was used in this case only on an empirical basis because the prothrombin time was markedly prolonged by the heparin before dicumarol could have had effect. The recovery was almost certainly due to prompt transfusion rather than the vitamin K.

Swelling of the thigh, however slight, suggests extension of the thrombus proximal to the inguinal ligament. Inasmuch as there was no abdominal or rectal tenderness and there was only moderate preoperative swelling of the thigh, initial exploration of the femoral vein in Scarpa's triangle was justified, as a loose thrombus extending only a short way proximal to this point can sometimes be sucked back, thus making abdominal surgery unnecessary.

Paravertebral sympathetic block with procaine, or by surgical interference as in the case presented, helps reduce the edema of the extremity. Interruption of the sympathetic pathways blocks vasoconstrictor impulses and thus allows better collateral circulation with resultant diminishing edema. It was noted that in this case the affected leg was warm and pink and at no time showed any effect from the venous ligation. It was believed that the sympathectomy contributed materially to the patient's recovery.

Finally, the dangers of heparin and dicumarol alone or with surgery must be considered and weighed against the dangers of surgery alone in each individual case.

### SUMMARY

1. A case of postoperative iliac venous thrombosis, treated with anticoagulants and surgery, is presented.

2. Both anticoagulants and surgery are useful in the prevention of fatal pulmonary emboli.

3. Sympathectomy in this case seemed to be of striking benefit. Sympathectomy or paravertebral lumbar sympathetic block with procaine might prove of value in every case. The sympathetics are in most cases readily accessible when large pelvic veins are operated upon and their removal should not increase the operative risk unduly.

4. Administration of heparin and dicumarol is potentially dangerous.

5. Prevention is the best therapy.

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Aneurysms vary in size from that of a millet seed to a child's head. They may be single or multiple. In order of frequency they involve the thoracic aorta, popliteal artery, femoral artery, abdominal aorta, subclavian artery, innominate artery, axillary artery, iliac artery and the cerebral and pulmonary arteries.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

# EXCISION OF THE ELBOW FOR MULTIPLE COMPOUND COMMINUTED FRACTURES*

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THE literature on this subject is scanty. Advocating excision of the elbow rather than an arthroplasty later may seem too radical. Certainly arthroplasty cannot be performed with hope of good results in all cases of stiff elbows. There must be indications for excisions in those cases involving severe trauma. Many English writers wrote extensively on its value as an immediate treatment accompanying débridment of gunshot wounds destroying the elbow joint.* They advised that if it be done early, infection and sepsis are prevented. They agreed that the triceps tendon and fascia should be kept intact and continuous with the periosteum and fascia overlying the ulna.

The length of the convalescent period is shortened, particularly valuable in patients who are dependent upon the use of their hands to earn a livelihood. The lateral instability is obviously not so important in a non-weight bearing joint, such as the elbow. It may be a crude surgical procedure but if the patient is satisfied, and can freely use the part in his work without pain or minimal discomfort, it is not an operation to be thrown into discard. A patient would seem to be better off than with a stiff elbow.

Buzby[1] reports satisfactory results in thirteen out of fifteen elbow joint excisions. One case was for an extensive compound comminuted fracture of the three bones. Nine were for post-traumatic ankylosis, all old healed compound comminuted fractures. Pain was almost a negligible factor from the time of the operation, and disappeared when motion began. Extension against gravity is the last function to recover, and lateral instability improved when the patient learned to hold the biceps moderately tight. All the patients reported earn their livelihood by hard physical labor.

Buchanen[2] says, "In this operation the joint ends of all bones are widely removed. Success here, in distinction to other joint operations, depends upon the wide removal of bone. There should be three finger's breadth between the arm and forearm bones in the extended position when placed in a moderate stretch."

Campbell[3] states that excision of the elbow is indicated when destruction is severe, but has reference to infection, and does not mention compound fractures. This procedure is not indicated in children.

Churchill[4] says in a few cases in which serious trauma or early established infection has irreparably ruined the joint architecture, resection of the joint has been performed and satisfactory healing in a position of maximum usefulness achieved. This obviously means that an arthrodesis results rather than a pseudoarthrosis. No doubt there will be more abundant literature on this subject from the surgical divisions of the military departments in the future.

Christopher[5] interestingly states that fractures of the lower end of the humerus, and upper end of the radius and ulna constitute one-tenth of all the fractures in the body, but no mention is made of elbow

* A. E. Moore, W. M. Shepar, C. M. Moullin, R. H. J. Swan, C. H. Fogge in the *Brit. M. J.*, in 1917–1918.

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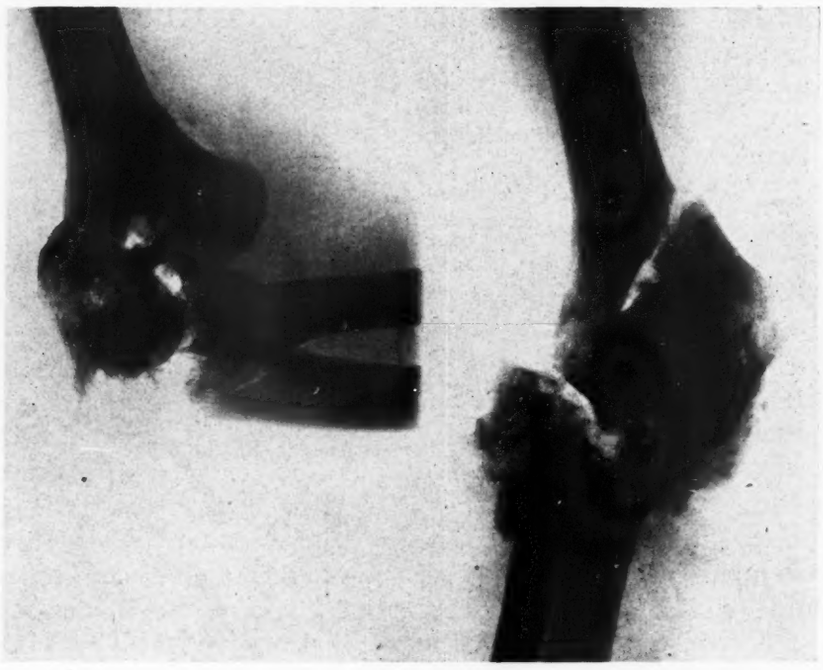
joint excision for severely comminuted compound fractures. Key and Connell[6] concur in this opinion.

in spite of instability and minimal pain. Their cases presented relatively the same indication; viz, severely compounded com-



A B

FIG. 1. *X*-ray film showing marked comminution involving fractures of the lower end of the humerus, and upper ends of the radius and ulna. Note the marked distortion of fragments, and absence of joint continuity.

Jones and Lovett[7] state: "It is an open question whether arthroplasty has sufficient advantage over excision to warrant one in pronouncing it the operation of election." This is a conservative evaluation.

Kini[8] advises that the bone ends should be kept apart in elbow excisions with the use of skeletal traction, followed by a short period of plaster of Paris fixation, and physiotherapy measures later. The power of flexion should be against resistance. Evaluation is based upon (1) the cosmetic result, (2) weight lifting (10 pounds), first with the affected arm hanging by the side, and secondly with the arm abducted and the forearm in full extension.

Levit[9] emphasizes that the best treatment for gunshot wounds of the elbow joint, complicated by fractures, is early resection with early therapeutic exercises.

McLaughlin and Smith[10] have done several cases with reasonably good results minuted fractures of the elbow involving the humerus, radius, and ulna.

Murray's[11] comments are most informative. Most of the cases presented in the literature were the result of gunshot wounds. He is impressed by the comparative rarity of flail elbows reported in the literature. Differentiation of those cases in which there is loss of bone forming the joint with good practical muscle and nerve control, from those in which there is loss of bone with loss of practical muscle and nerve control, must be made. The former are classified as active flail elbows. The findings in this case report indicate the former classification. Murray recommends restoration of the normal shape and size of the bone ends affording better contact for resistive pressure. A good pad of fibrous tissue that will obviously form between the bone fragments ought to substitute reasonably well however, in the writer's opinion.

Scudder[12] says, "Fractures of the lower end of the humerus entering the elbow joint are generally recognized as giving relatively poor functional results. Treatment of an adult elbow joint fracture should be very carefully thought out from the date of the injury. Partial excision of the elbow has been followed by satisfactory results in a few cases in which it has been used."

Shorbe[13] in a very interesting review of severe elbow injuries associated with automobile door etiology, i.e., driving with the arm resting on the car door sash and protruding, states that in extensive comminution of the lower end of the humerus early removal is the best form of treatment. Results are surprisingly good in spite of instability and some weakness. The results in his series were uniformly bad in the severe cases with the use of skeletal traction in selected forms and occasionally open reduction with fracture assembly. It would seem that with such poor results using the usual accepted fracture management, elbow joint excision, particularly if an active flail elbow may be obtained, should enter the plan of treatment more often. This obviously refers to the severely comminuted compounded fractures. The argument may be advanced that even should ankylosis occur, arthroplasty may be done later.

Speed[14] states that in the severely compound comminuted fractures, complicated by infection, ankylosis is to be expected. Reconstruction measures are advocated at a later date.

West[15] says in supracondylar fractures of the humerus of the worst type with practically no movement as an end result, an excision may be considered if the patient is willing to sacrifice stability for movement. It has been the writer's experience in this type of case to observe many cases of ankylosis.

The following case report is submitted, suggesting consideration of this procedure in selected cases.

## CASE REPORT

A white male, fifty-five, janitor, was admitted to Hurley Hospital, Flint, Michigan

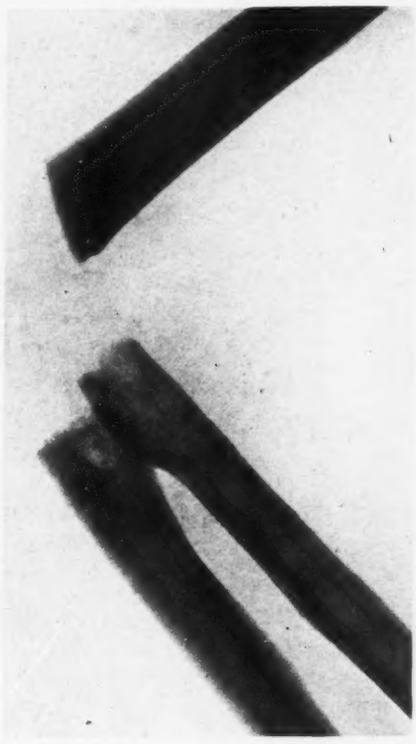


FIG. 2. Postoperative *x*-ray film showing complete elbow joint excision.

on August 30, 1944, at 10:30 A.M., about one-half hour after falling from a height of two stories and sustaining injuries involving the right shoulder and elbow. There were no associated injuries and his general condition was good.

Clinical examination of the right shoulder revealed nothing significant. There was some ecchymosis with generalized edema and tenderness. *X*-ray examination later showed a fracture in the mid-scapular area without displacement. The right elbow, however, showed a large, deep, jagged gaping transverse wound about three inches in length, on the posterior aspect about the level of the humeral condyles. There was moderate bleeding, and the wound was contaminated with dirt. The slightest movement was painful. Deformity was present, but there were no evidences of associated radial or ulnar nerve involvement. *X*-ray examination showed "comminuted fractures of all bones of the elbow joint."

The patient was a good surgical risk and was accepted for immediate exploratory operation.

The original wound was of adequate size for this purpose. Meticulous local preparation was done, viz, shaving, thorough scrubbing with green soap, and copious saline irrigation. Identification of structures was attempted. The radial and ulnar nerves were not seen. The triceps tendon was completely detached with the olecranon fragmentation. The comminution was marked and there were many bone fragments of all sizes and shapes in distorted positions. The humeral condyles, radial head, olecranon, and a portion of the ulnar shaft were identified in numerous pieces. There was marked devitalization of overlying soft structures, with much dirt deposited in the wound. The biceps tendon was intact at its radial attachment. Assembly of the many bone fragments into some degree of relationship was considered mechanically impossible. The hazard of secondary bone infection and necrosis was great, and at best a fixed elbow in a selected position of optimum use was all that could be expected under the most ideal circumstances. There no doubt would have been persistent sinuses for a long time.

Complete excision of the elbow was selected. The loose bone fragments were first removed. Devitalized soft tissues were excised, hemostasis secured, and the jagged humeral, ulnar, and radial bone ends were sawed off, leaving the clean smooth stumps. The biceps tendon attachment was preserved. The wound was again thoroughly irrigated with normal saline, the triceps tendon remnant sutured to the posterior deep fascial plane of the forearm, and the wound closed with cotton sutures. About 7 Gm. of sulfanilimide powder were dusted in the wound. The arm was placed at right angles and laid on a pillow, following application of a loose dressing. The whole operative procedure took about one and one-quarter hours.

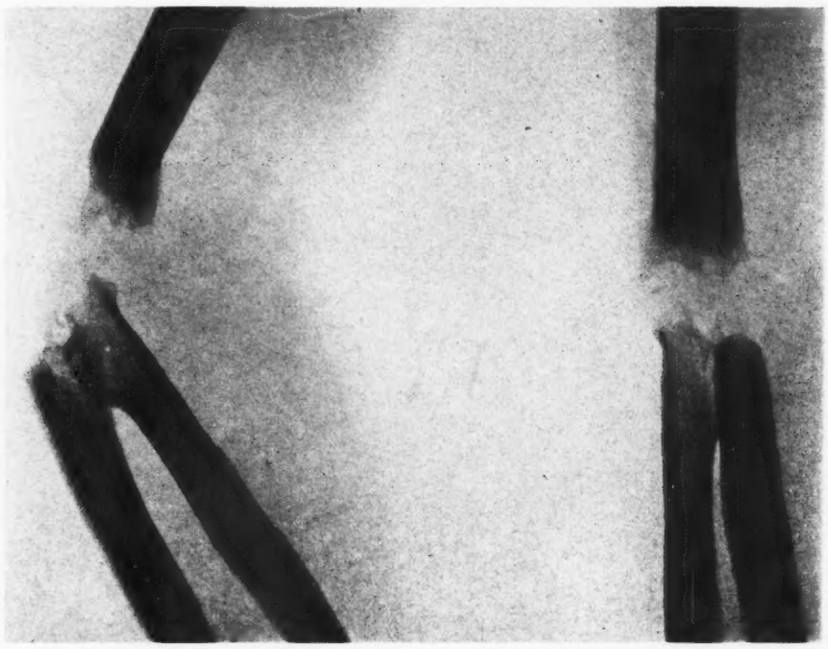


FIG. 3. Progress *x*-ray film, eight months postoperatively. There is some osteophyte production and spur formation present, with ample space between the bone ends.

The patient's reaction was good, and the postoperative course was afebrile after the first two days. Five Gm. of sulfathiazole were given orally in divided doses every twenty-four hours for the first six days. Pain was minimal. The wound healed by first intention, and physiotherapy was started on the tenth postoperative day, directed toward active and passive movements principally. The patient was ambulatory on the twelfth day, with the right arm in a sling. He was discharged from the hospital on the nineteenth postoperative day, September 18, 1944, with no significant complaints. There was beginning active forearm flexion and one could see the biceps muscle in play. Triceps function was minimal.

Close observation was given this case, and

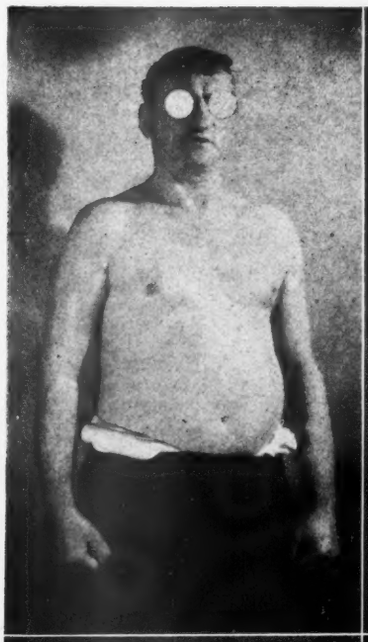


Fig. 4.

Fig. 5.

Fig. 6.

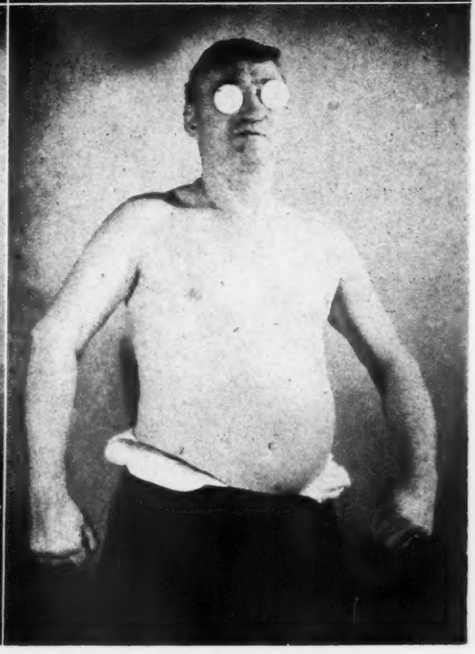


Fig. 7.

Fig. 4. The patient, eight months postoperatively, with the right upper extremity hanging at his side, in complete extension, with the forearm in pronation.

Fig. 5. Right forearm at right angles midway between supination and pronation. Note the contour of the contracted biceps muscle.

Fig. 6. Right forearm in almost complete flexion, with the arm hugging the lateral chest wall.

Fig. 7. Right arm abducted 35 degrees, with forearm in pronation. Note absence of visible deformity at right elbow. Both upper extremities are relatively the same size.

careful but constant physiotherapy measures were carried out postoperatively for months. The patient returned to light duty on the

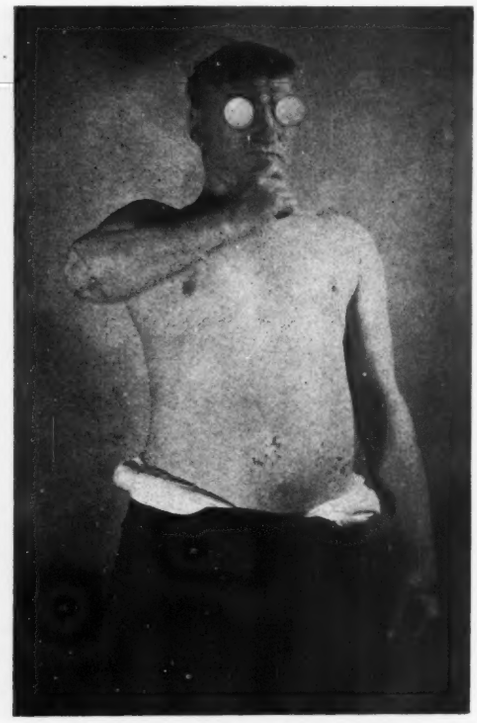


FIG. 8. Right arm in 75 degrees abduction, with forearm in complete flexion, and in mid-supination and pronation. Note healed transverse scar on the posterior aspect of the elbow.

fortieth postoperative day, and at present, is conducting the major portion of his pre-trauma work. There is no pain. The elbow is flail and unstable but very useful. Flexion is complete. There is minimal triceps function. Grip is good in the right hand and the patient is able to lift about ten to fifteen pounds. The convalescence was definitely shortened. The accompanying *x*-ray films and photographs are self explanatory. (Figs. 1 to 8.)

SUMMARY

A case report is presented describing the care of a severe, compound, comminuted fracture of the right elbow by complete joint resection. The satisfactory result obtained would give the impression that this procedure has merit in such cases and should receive consideration in the plan of management.

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# TRAUMATIC BRAIN ABSCESS AND MENINGITIS*

## CURE EFFECTED WITH PENICILLIN AND SULFADIAZINE

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IF one reviews the surgical treatment of brain abscess, such a wide divergence of opinion will be found that we may readily conclude that the accepted treatment is still to be determined. Peculiarly enough the pyogenic organisms primarily responsible for brain abscess are controlled by the sulfonamides and penicillin. The organisms most frequently encountered in brain abscess are: Streptococcus pyogenes, Staphylococcus pyogenes aureus, pneumococci, hemolytic streptococci, occasionally colon bacilli and gas forming spore-bearing anaerobes, and Bacillus typhosus. In view of the questionable results obtained in the treatment of these abscesses it was considered of interest to report the case of brain abscess associated with meningitis in which we are certain the patient would have succumbed had not surgery been combined with the use of sulfonamide and penicillin.

Infections may enter the brain through four separate pathways; (1) by direct extension along the blood vessels, Virchow-Robin spaces, preformed pathways, nerve sheaths, or foramina; (2) by direct implantation from penetrating wounds; (3) by means of infected emboli carried through the blood stream, and (4) by unknown pathways.

The most frequent cause of brain abscess is otitis media and mastoiditis. In Evans' group of 194 cases, 56.8 per cent arose from this area, whereas in a series of Courville and Nielsen 46 per cent had a similar origin. Suppuration in the nasal cavity and accessory sinuses was the cause in 6.3 per cent of Evans' group; invasion of the brain by malignant growth in 1 per cent, and metastatic suppuration in 23.7 per cent. Approximately one-half of the metastatic group arose from either chronic bronchiectasis or empyema, and the other half from extrathoracic suppuration. Metastatic abscesses carry with them a high mortality partly because approximately 50 per cent are multiple.

The frequency of brain abscess fortunately is small. In a series of 94,469 cases, Dench discovered eleven patients with brain abscess. Courville and Nielsen in reviewing the statistics of the continental clinics, found 0.19 per cent, 277 instances with brain abscess in a total of 147,604 cases. The frequency of brain abscess occurring in otitis media also is extremely small. Evans reporting on 10,280 autopsies from the London Hospital found 718 cases of otitis media, with seventy-four, or 10.3 per cent with brain abscess. In 45,272 autopsies sixty-eight, or 0.15 per cent revealed brain abscess.

Brain abscess also rarely follows head injury unless the dura is penetrated. Holmes in a series of 2,357 post-war head injuries found twenty-seven cases of abscess, or 1.4 per cent. They occurred only when the dura had been opened. Tuffier and Gualian in a series of 5,644 post-war head injuries found ninety-four, or 1.4 per cent with abscess.

Macewen, in 1893, reported on a series of twenty-five cases of abscess, six patients of whom were moribund and died without operation. The other nineteen were operated upon and eighteen recovered. He evacuated the abscesses completely, re-

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peatedly washed out the cavities with antiseptic solution and rarely used a drain. In the cases in which the capsule was old and thick and failed to collapse, he used such drains as decalcified chicken bone which later became absorbed, or rubber or glass. These spectacular results of Macewen were due to a combination of the drainage method later advocated by Elskey and Coleman, the tapping method of Dandy, and the unroofing technic of King.

Objections were found to the use of rubber tubes because they often collapsed and to glass tubes because they became dislodged, penetrated the brain substance and spread the suppuration. All types of tubes were found to be forced out from the brain and the dressings were difficult and dangerous. For this reason they were replaced by gauze drains, but as the gauze became moistened with pus, it acted as a plug, thus naturally defeating its purpose. Cigarette drains were also tried, but without success. However, folded layers of guttapercha were an added improvement. Success was obtained by the use of the wire gauze drain of Mosher. The improvement in rubber tubing led to the reintroduction of the rubber drain by Coleman. Later, the unroofing method was suggested by King.

The modern surgical treatment of brain abscess may be divided into three groups: (1)closed method with drainage or tapping; (2) open method and (3) extirpation.

*Closed Method.* If the indication for immediate puncture is not too urgent, the wound should be packed with gauze soaked in a mild antiseptic solution, and the dura, arachnoid and pia about the opening should be coagulated with the electrosurgical unit. The incision should then be closed, and reopened within twenty-four to forty-eight hours. When the needle is introduced into the abscess and the smear does not reveal any bacteria, one or two aspirations may be sufficient to clear the abscess. This method was later suggested by Dandy. Successful cases have been reported by Grant, Puusep, Spasokukotsky, Patrikios and Sbarounis, Vincent et al. If the pus, on the other hand, contains many organisms, a rubber drain is placed through the opening and into the abscess. A special needle described by Grant is of value in inserting the tube. The rubber tube is sutured to the galea and the wound closed around the tube. The tube is left *in situ* for a week, then the suture is cut and the tube is allowed to extrude itself in the course of two to three weeks. Worms and Ferey have suggested repeated aspirations of pus through the tube. Coleman reports twenty-six cases with twenty-one recoveries and Grant reports twenty recoveries in thirty cases.

*Open Method.* Once the capsule of the abscess has been identified by the exploring cannula, the opening is enlarged in the skull. The dura is opened in a stellate fashion and the subarachnoid space is sealed off by packing gauze soaked in ¼ strength of iodine between the dura and the arachnoid for twenty-four hours (Bucy), or suturing the dura to the cortex with fine catgut (King and Adson), or by coagulating the dura, arachnoid and pia to the cortex with the electrosurgical unit (Cahill and Horrax). The cortex is now either incised, (Adson and McKenzie) down to the abscess wall, or excised and removed with the electrocautery or suction (Bucy, Kahn, King, Toby, Bagley), until the surface of the capsule is exposed. The surrounding brain is held back by general retraction, the pus is evacuated through the exploratory needle, the abscess cavity is opened and the remaining material is sucked out under direct vision. The abscess cavity is then packed and kept open with gauze, or a soft rubber tube is inserted in the cavity without gauze (McKenzie); the cavity may be filled with long strips of rubber tissue (Robinson); or iodoform gauze be packed about two soft rubber catheters (Adson, Bucy); iodoform gauze alone may be used (King); a conical wire mesh basket has been suggested as a drain (Mosher). Horrax evacuates the pus

and sutures the capsule to the galea or pericranium, thus marsupializing the abscess. Kahn identifies the abscess cavity and introduces thorotrast into the cavity after removal of pus. The abscess then slowly progresses outward toward the surface of the brain. As a rule, however, the cortex herniates through the operative wound as the abscess migrates toward the surface. The protruding brain is removed by suction, the abscess cavity being opened, evacuated, marsupialized, packed and drained.

On one occasion the authors permitted the brain to herniate out through the opening and the entire abscess capsule extruded with the herniation, so that we were able to resect the abscess away from the surface of the brain.

In all of these variations of the open method, removal of the pack begins after one week and is completed between the tenth and twelfth days.

*Extirpation.* Vincent was the first deliberately to remove an encapsulated posttraumatic abscess. In case the abscess membrane was thin, and would not permit enucleation, Vincent performed repeated drainage with decompression so as to permit a thickening of the abscess wall. Enucleated abscesses have been removed successfully by Vincent, Morton, Dott, Cairns, and Adson.

## CASE REPORT

On November 21, 1943, H. H. a male, aged sixteen, was in an automobile accident, entering the Permanente Hospital unconscious and in deep shock. Hemorrhage from the nose and mouth and a subconjunctival hematoma of the right eye were found. Spinal fluid as well as blood was draining from the nose. Physical examination the following day after the patient regained consciousness revealed a well developed male lying quietly in bed. There was an area of contusion over the left frontal region and marked tenderness over the left orbit. Temperature was 97.2°F., pulse 92, respirations 22, blood pressure 130/60. Corners of the mouth were well and equally elevated; there was no evidence of facial nerve injury. Pupils were equal and reacted to light and accommodation. Extra-ocular muscles were normal. Vision was roughly normal with normal fundi and sharp disc edges. The left drum was retracted. However, there was no bleeding. There was a loss of the sense of smell. There was a clear fluid dripping from the nose whenever the patient would roll from side to side. The pharynx was clean, the neck glands palpable but not tender and the trachea was in the midline, the thyroid was not enlarged, the lungs were clear and the heart was not enlarged nor were there any murmurs or irregularities. Examination of the abdomen was negative for injury. Abdominal reflexes were normal. No evidence of back injury was noted, there was no tenderness to kidney percussion and the genitalia were normal. No hernia existed in either groin, the cremasteric reflexes were normal, the extremities revealed no evidence of injury; the reflexes and sensation were normal and equal.

*X*-rays taken on November 21, 1943, revealed a fracture involving the frontal sinus and base of nose on the left, and a slight depression of the superior rim of the left orbit. This fracture involved both tables of the skull with slight depression of the inner table. There was also a fracture involving the petrous portion of the temporal bone on the left which extended forward.

Urinalysis on November 22, 1943, revealed a clear yellow specimen. Reaction 5.0; specific gravity 1.028; pus 2–3; few epithelial cells; few mucous threads; and a few clumps of pus cells. It was negative for albumin, acetone, or red cells. Blood count on November 22, 1943, revealed a hemoglobin of 85 per cent; red blood cells 4,490,000 and white cells 9,000.

The patient remained flat in bed for one month. The leakage of cerebrospinal fluid from his nose stopped within the first week. During the remainder of the time, the patient suffered no unusual symptoms. Temperature, pulse, respirations and blood pressure all remained constant. The patient was dismissed from the hospital to bed rest at home on December 23, 1943. on January 4, 1944, he was allowed to sit up at home. On January 19, 1944, he was seen in the clinic. The fluid was dripping from his nose rather profusely. The fluid would stop dripping when the patient remained flat on his back. Hospitalization was strongly advised; however, the parents would

not consent to this. The patient was placed at bed rest at home. He remained in bed until March 15, 1944, at which time he was allowed to remain out of bed for short periods of time. The rhinarrhea did not reoccur.

On April 8, 1944, the patient was readmitted to the hospital because of nausea, vomiting and headaches. On physical examination at this time, there was found to be a slight stiffness of the muscles of the neck. The eye grounds showed marked papilledema bilaterally of approximately four diopters. Sense of smell was absent in both nostrils. His temperature was 99.6°F., pulse 76, respirations 18. There was a paralysis of the sixth nerve of the right eye with an inability to move the right eye laterally beyond the midline. Other ocular muscles were intact and normally active. The right pupil was larger than the left; both reacted to light, but very little reaction was noted to accommodation. There was no gross limitation of visual fields. Kernig sign was negative. Spinal puncture on April 10, 1944, revealed a pressure of 440 mm. of water with 7 red blood cells per high power field. Spinal puncture on April 15, 1944, revealed a pressure of over 600 mm. of water with 10 red blood cells per high power field. It was believed that increase in pressure was caused by a space occupying mass on the left side. On April 17, 1944, examination revealed temperature 98°F., pulse 70, respirations 18, blood pressure 120/70, sense of smell absent bilaterally. Diplopia was present and there was a right rectus paralysis. The right pupil was larger than the left; both pupils reacted to light, but there was little reaction to accommodation. There was no gross limitation of the visual fields. Discs showed marked choking bilaterally. Cranial nerves 6, 7, 8, 9, 10, 11, 12 were intact. General sensation was intact. Two point discrimination was negative. Vibratory sense showed no abnormality. Upper abdominal reflexes were hypoactive compared with the lower abdominals, cremasteric bilaterally active, arm reflexes normal. The patellar and Achilles reflexes were more active on the right. There were no pathological reflexes. Urinalysis on April 17th was negative to albumin and acetone. It contained 1.5 pus cells per high power field, abundant amorphous deposits, specific gravity 1.018, negative to sugar and a few triple phosphate crystals. Blood count on April 17th revealed hemoglobin of 93 per cent; leucocytes 8,100, erythrocytes of 4,700,000 and a color index of 0.97. The Kline test was negative.

It was our opinion that we were dealing with either a brain abscess or a subdural hematoma. In view of the slightly increased reflexes on the right and because of the history of rhinorrhea a left-sided frontal lesion was suspected. The entire head was shaved and the patient prepared for bilateral frontal perforator and burr openings, under local anesthesia.

The head was prepared in the usual manner with green soap, sterile water, bichloride and alcohol. Local anesthesia was infiltrated in both frontoparietal areas, about midline between the base and the vertex. A small incision was scratched over both of these areas and the field was then draped. With the assistants making digital compression to control the bleeding, an incision was first made on the left side. Hemostats were applied to the galea and a self-retaining retractor was inserted. With the periosteal elevator the scalp was separated from the calvarium. A perforator and burr opening was made through the skull; the dura was tense, but there was no evidence of hemorrhage. The dura was then opened and the brain found to be under considerable pressure; there was no evidence of a subdural hemorrhage. The wound was packed with cotton gauze, and a similar procedure carried out on the opposite side.

In view of the possibility of a left-sided abscess, a brain cannula was first inserted into the right cerebral hemisphere to rule out the question of deep-seated brain hemorrhage, or multiple abscess. Nothing was found on the right side. The wound on the right was then completely closed with silk sutures and a silver-foil dressing applied. An exploratory cannula was then inserted into the left frontal lobe and at a distance of 6 cm. a soft area was encountered which immediately drained thick, greenish yellow pus. A stilette was introduced into the cannula which was then replaced by the brain abscess guide of Grant. Through this guide a small rubber catheter was introduced. We were able to evacuate 75 cc. of thick pus. The abscess cavity was then washed with saline. A smear was obtained and the laboratory reported the probability of a pneumococcic organism. Culture later proved this to be pneumococcus, type III. Penicillin, 25,000 units, was dissolved in 10 cc. of water and this solution was directly instilled into the abscess.

The abscess cavity had contracted, so that it was possible to instill only 8 cc. of the penicillin solution. The remaining 2 cc. were instilled over the cortex and in the surrounding scalp. The dura was not closed. The rubber tube was sutured to the galea and the wound closed with silkworm gut. A dressing was applied and the drain was clamped shut, to keep the penicillin in the abscess cavity. The patient left the operating room in good condition.

Postoperatively on April 18th the patient's temperature was 100.2°F., pulse 100, respirations 24. When the clamp was released from the drain and the drain opened, approximately 10 cc. of bloody purulent fluid escaped from the abscess cavity. Penicillin, 25,000 units were again placed into the abscess cavity after washing with saline. During the washing the patient complained of pain over the right eye. Pulsation was noted in the fluid in the catheter during irrigation. Smear of the material drained from the wound revealed many red blood cells, few pus cells and a few diplococci. Culture revealed the organisms to be pneumococci, type III. Physical signs were unchanged other than that the stiffness in the neck had increased.

On April 19th, his temperature was 101.2°F. pulse 110; respirations 24; on opening the tube approximately 5 cc. of bloody fluid oozed forth. Smear from this specimen revealed many leucocytes and erythrocytes, but no bacteria were seen. The wound was irrigated with saline. There was some resistance felt after about 5 cc. of saline had been placed in the cavity; 25,000 units of penicillin were placed into the cavity. The suture holding the drain in place was cut, and the entire drain was forced out. Spinal tap revealed 41 leucocytes, 13 erythrocytes per cu. mm. During the afternoon the patient's temperature rose to 102°F., pulse to 120. Sixth nerve paralysis was still present. The patient was placed on sulfadiazine. On April 20th the sulfa level in the blood was 23.5 mg. per cent.

On April 21st, his temperature was 100°F. Cisternal puncture and spinal puncture were done and revealed a pressure of 300 mm. with no block present. His pulse was 100, respirations 22. The cell count from the spinal fluid was 72, and from the cisternal fluid 129 cu. mm.; 25,000 units of penicillin were injected into the spinal canal.

On April 22nd his temperature was 98.9°F., pulse 94; respirations 22. Spinal fluid pressure was 480 mm. with a cell count of 54 per cu. mm. Ten cc. of fluid were removed and 25,000 units of penicillin in 4 cc. of fluid was again administered into the spinal canal.

On April 23rd his temperature was 98.6°F., pulse 86, respirations 20, spinal puncture revealed a pressure of over 600 mm. of mercury. This pressure was due to the fact that the patient was not cooperative and was straining. There were 10 erythrocytes per high power field; no white blood cells; 25,000 units of penicillin were again administered into the spinal canal. The sulfa level (blood) was 11.7 mg per cent. The white cell count 9,800, red cell count 4,500,000. The urine was essentially normal and showed no crystals.

On April 27th, his temperature was 98.8°F., pulse 86, respiration 20. Spinal tap showed a pressure of 300 mm. of mercury; 10 cc. of fluid were removed and the pressure dropped to 140. Cell count revealed 10 lymphocytes and 6 polymorphonuclears with 84 red blood cells. The blood sulfa level was 11.5 mg. per cent.

On May 1st, his temperature was 98.6°F., pulse 90, respirations 16. No unusual signs or symptoms had developed. The wound was clean, and sutures were removed. There was still papilledema in both eyes. Sixth nerve paralysis was still present on the right side. There was more strength in the right hand than in the left. Abdominal reflexes were absent.

On May 3rd, his temperature 98.2°F., pulse 98, respirations 20; a spinal puncture revealed a pressure of 280 mm.; 5 cc. of fluid were removed. The cell count revealed 21 red blood cells and 1 white blood cell. The wounds were clean. The sixth nerve paralysis on the right was still present. Weakness of the left hand was still present, however, no other neurological signs were found.

On May 11th, the patient was dismissed from the hospital to be followed in the out-patient clinic. His temperature was 98°F., pulse 84, respirations 20.

On May 25th, the patient was examined in the out-patient clinic and found to be in good physical condition. The wounds were clean. The right eye now moved readily to the midline only. Knee jerks were slightly hyperactive but equal. Eye discs were still choked. The sense of smell was still absent.

On June 27th, the patient had been up walk-

ing around without difficulty. Pupils were equal and regular, reacted to light well and the discs showed no papilledema. There was partial lateral right rectus palsy, and the patient was attending school.

On July 26th, the right eye moved to almost complete range of normal motion. He had no neurological symptoms, no complaints or signs of recurrence of brain abscess, and had been working for almost two months.

On December 15, 1944, the patient had no complaints and was working actively. Examination revealed him to be completely normal.

SUMMARY

This patient with brain abscess was cured by three direct instillations of penicillin into the abscess cavity for a total of 75,000 units, and the resulting meningitis arising therefrom was treated by an additional 75,000 units of penicillin injected into the spinal canal, plus the use of sulfadiazine.

OSTEOMYELITIS of the skull may be the result of trauma, hematogenous infection, direct extension from infections of the nasal sinuses or mastoid, syphilis, or tuberculosis. It may be localized or spreading. The common infecting organism is Staphylococcus aureus.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# THROMBOSIS OF THE BRACHIAL ARTERY TREATED WITH SUCCESSIVE CERVICAL SYMPATHETIC BLOCKS

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SYMPATHETIC chain block is now recognized as a valuable procedure in the management of several different clinical conditions. These conditions include thrombophlebitis, causalgia, certain severe chest injuries, and occlusive arterial lesions of both sudden and gradual onset.[1–6] Viability of an extremity may be threatened by the sudden occlusion of a major artery and it is in such cases that this method of treatment may yield most spectacular results by producing sufficient vasodilatation in collateral channels to overcome the critical circulatory deficit.

Traumatic arterial injuries may result in perforation of the vessel, thrombosis of a vessel without perforation or in a severe spasm of the arterial wall which at times is sufficient to shut off the flow of blood through the vessel.[7] Also, in some cases in which there is a perforating wound or thrombosis of a main vessel; the collateral vessels may undergo a spastic contraction which further diminishes the circulation to the part distal to the lesion. The case reported below is not especially unique, however, it is an excellent example of the striking benefit that in some cases may be derived from repeated sympathetic blocks.

## CASE REPORT

The patient, a well developed twenty-nine year old soldier, was admitted to the hospital at 3 P.M. September 2, 1944, one hour after being in a truck accident.

The history revealed that the patient was riding in a truck when it ran off an embankment 45 feet high. The patient was thrown to the ground, and his right arm at a point 2½ inches below the axilla was pinned to the ground by the gate of the truck body. Thirty minutes elapsed before the truck gate was removed, thereby releasing the patient. The patient experienced pain at the site of the contusion of the right arm and right lateral chest wall and also experienced pain in the left shoulder. On admission to the hospital his general condition was fair, the patient was conscious and there was no evidence of severe shock. Examination in the receiving office revealed the presence of a simple fracture of the left clavicle and contusions of the right chest wall, right arm and right side of the face. No radial pulse could be felt on the right. A normal brachial pulse could be felt in the right arm above the site of the contusion where the truck gate had compressed the arm for thirty minutes. Sensation as tested by cotton and pin prick was greatly impaired. Movement of the fingers and thumb were almost absent and there was some weakness of the extensors of the right wrist. The right hand was definitely cooler than the left and was moist. Slight cyanosis was present. There was no evidence of a large hematoma, pulsating, or otherwise, in the arm although a definite contusion with ecchymoses was present. The impression at this time was that the patient had a severe spasm of the right brachial artery.

At 6:20 P.M. a right cervical sympathetic block was performed with 2 per cent procaine. Following this, the arm felt slightly warmer, however, the results were not conclusive.

Precautions were taken to see that no form of heat was applied to the right arm. Heat in the form of hot water bottles was applied to the trunk and to the lower extremities in an effort to produce reflex vasodilation.

At 9:30 P.M. aminophyllin was given intravenously and another cervical sympathetic block was done. Papaverine, which might have been given, was not available. Thirty minutes after the second sympathetic block, the right arm and hand were dry and definitely warmer than previously, however, the right side was still cooler than the left and the pulse still could not be felt at the wrist. Sensation appeared to be better but was definite by not normal. Two and one-half hours after the block,

the forearm and hand had again become cold, therefore at midnight a third block was done. The effects of this block likewise persisted for only two and one-half hours and the procedure was repeated at 3 A.M. and again at 6 A.M. Following the sympathetic ganglion procaine injection, performed at 6 A.M. September 3, 1944, the hand remained warmer than at the time of admission. Sensation from this time on remained much better than during the first few hours following admission. At 9 A.M. the hand was still fairly warm. The hand did not become cold again, however, another block was performed at 11 A.M. and again the following day.

A very weak but definite radial pulse at the right wrist was found by various observers seventy-two hours following the injury. This pulse could be felt at times for a period of three days, after which it could no longer be demonstrated. Sensation returned to normal, however, the patient was unable to use the intrinsic muscles of the hands more than 50 per cent of normal and there was some weakness of the forearm. Wrist drop was not present. The patient was kept in bed for one week after which time the left shoulder was immobilized with a bandage and physiotherapy in the form of active and passive exercise for the right hand was begun.

On September 15, 1944, because it was felt that a long period of time would be required before recovery from the contused ulnar and median nerve would take place, the patient was transferred to a general hospital. September 30, 1944, the patient was seen again. His general condition was about the same, the radial pulse on the right was absent. A brachial pulse above the point of contusion was present.

It is now believed that this case is one of thrombosis of the right brachial artery with an associated contusion of the right median and ulnar nerves. At the time of admission the circulation of the right arm appeared to be definitely deficient. Important points in treatment were frequent sympathetic blocks and the avoidance of heat to the arm. The patient was also prevented from smoking during this period.

It is interesting that the effects of the earlier sympathetic blocks lasted only two and one-half hours, while at a later time when the balance of circulation had been restored the effect was more prolonged. This emphasizes the importance of performing blocks as frequently as is shown to be necessary by examination, instead of on an empirical basis of two to four times a day. Alcohol injections would of course produce a more lasting effect. Since alcohol, however, is more likely to be associated with unfortunate complications than procaine, such as a severe neuritis, the author has preferred to rely upon the repeated use of procaine or upon sympathectomy produced by surgery, rather than upon the injection of alcohol. The fact that the radial pulse failed to return speaks for thrombosis rather than spasm of the artery.

*Comment.* The management of injuries of the large arteries is a problem of paramount importance in both civil and military practice. In some cases in which a major artery has been partially severed, the most widely practiced procedure is ligation of the artery after complete division, accompanied by ligation of the concomitant vein. Following this, all possible methods are used to secure the maximum amount of dilatation of the collateral channels. This is usually accomplished by successive procaine sympathetic chain blocks, or by this procedure followed by sympathectomy. Sympathectomy in the lumbar region has usually been associated more consistently with satisfactory results, than have operations of this nature performed in the cervical region.[8] This is apparently due to the fact that the lumbar region operation interrupts the pre-ganglionic fibers, whereas in the cervical region the post-ganglionic fibers are the ones interrupted.

The method of re-establishing the continuity of a severed artery as described by Blakemore, has recently received favorable comment.[9,11] Blakemore described a non-suture method of arterial anastomosis, in which a vein graft which bridges the defect is held in place by small vitallium tubes. This contribution will undoubtedly play an important part in saving some extremities from gangrene, however, the war cases to which the method is applicable are limited. Also, as with any method the

results are not always satisfactory, as thrombosis or blow out may later occur at the site of the anastamosis.

A procedure recommended in a number of standard books for the treatment of severe arterial spasm, with interruption of blood flow is resection of a portion of the artery. This is based on the assumption that the sympathetics will be interrupted distal to the division of the artery and, that this also may cause the release of some of the vasospasm in collateral channels. This procedure does not appear to be entirely rational when a sympathetic block can be more easily performed and if successfully done removes far more of the vasoconstrictor impulses affecting an extremity than would be accomplished by merely dividing the artery. Similarly sympathectomy may be performed in certain cases giving a constant and prolonged interruption of the vasoconstrictor fibers.

The deleterious effect which may be produced by applying heat to an extremity suffering from a deficient blood supply is now widely appreciated. Several years ago Norman Freeman pointed out that heating a part speeds up metabolic processes thereby making the demand for oxygen greater, and in cases in which it is impossible for this oxygen lack to be compensated by an increased blood flow tissue necrosis is more likely to occur. This point has been repeatedly emphasized by writers dealing with this subject. It is well known that external heat applied to other parts of the body such as the trunk and uninvolved extremities, may result in reflex vasodilatation all over the body and as such, this is a rational form of therapy.

In the author's experience, vasodilator drugs have not been of great benefit in such cases, however, papaverine given in rather large doses has often been recommended.

## SUMMARY AND CONCLUSIONS

1. A case of thrombosis of the brachial artery, treated by frequently repeated cervical sympathetic blocks is presented.

2. Procaine sympathetic block is a well established form of therapy in the management of injuries to major arteries.

3. The importance of repeating such blocks as often as is necessary, to maintain adequate collateral circulation is emphasized.

4. Some of the important principles in the management of injuries of the larger arteries are discussed.

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# DIVERTICULITIS OF THE VERMIFORM APPENDIX*

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DIVERTICULOSIS of the vermiform appendix is exceedingly rare and diverticulitis is even more infrequent. A case of appendiceal diverticulosis with superimposed subacute inflammation has been observed recently and is recorded here as a clinical oddity.

FIG. 1.

FIG. 2.

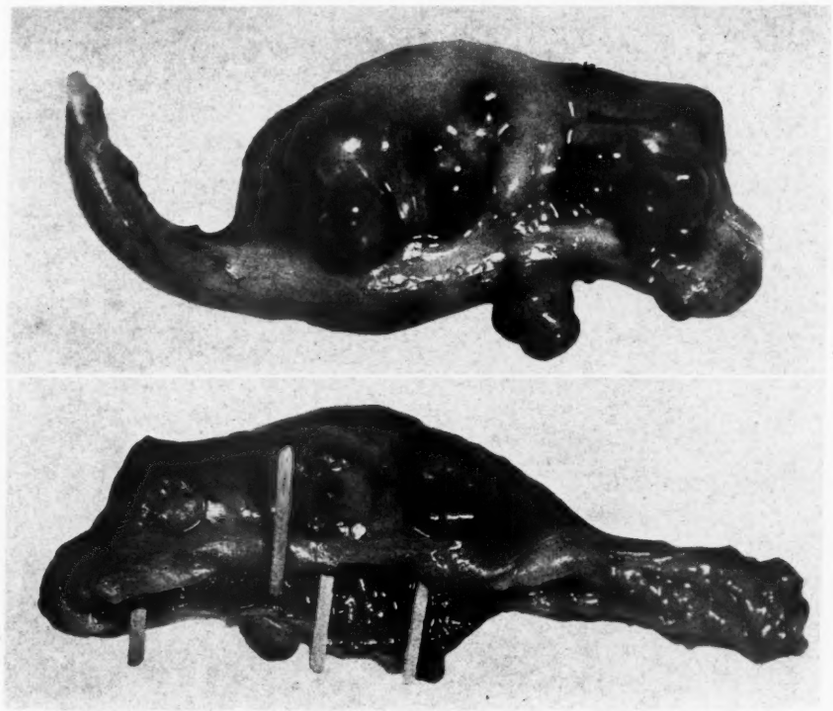

FIG. 1. Showing the appearance of the appendix and diverticula immediately after operation.

FIG. 2. Showing the communications of the diverticula with the lumen of appendix.

## CASE REPORT

M. A., a white female, aged twenty-two, was first seen on August 20, 1943, complaining of recurrent attacks of colicky right lower quadrant abdominal pain of ten days' duration. The pain was associated with nausea and constipation but not with vomiting, anorexia or fever. There had been no remarkable loss of weight, dysuria or respiratory complaint.

Three months before she had had a spontaneous miscarriage and her convalescence was uneventful.

Physical examination revealed a well developed and well nourished white adult female who did not appear ill. The temperature was 98.6°F., pulse rate 84, and respiratory rate 22. The head, neck, heart and lungs were essentially normal and the blood pressure was 118/82. The significant physical findings were limited to the abdomen where a moderate amount of tenderness to deep palpation was present. The tenderness was not sharply

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localized and was not associated with muscle spasm nor rebound tenderness. The pelvic examination was not remarkable.

Because she continued to complain of the colicky abdominal pain during the following three weeks under this therapy, she was admitted to the hospital on September 14, 1943, for observation and appendectomy. Operation was performed through a McBurney incision and a rather large appendix was found. Multiple large sacculations were evident on the surface of the appendix and in its mesentery. (Fig. 1.) These were diverticula, two of which showed gross evidence of inflammation. Appendectomy was performed in the usual manner and the ligated stump was inverted by means of a purse-string suture of fine black silk. The

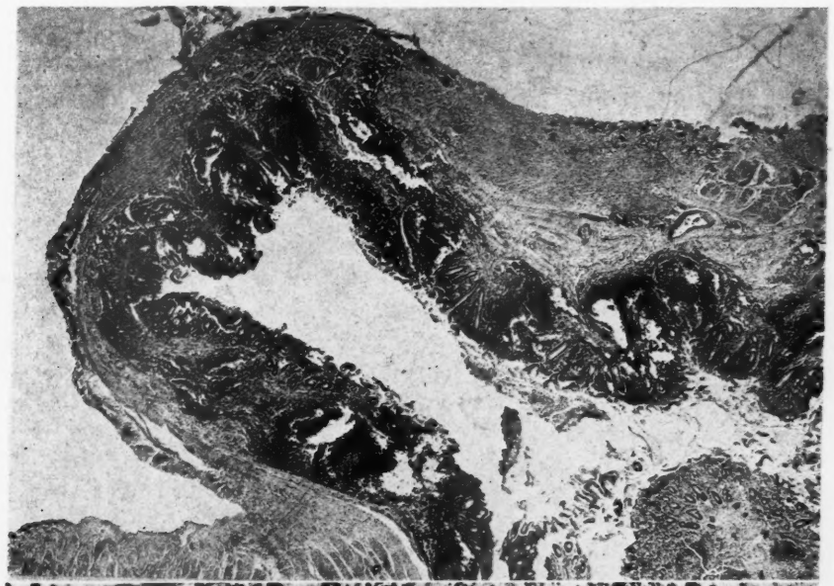

Fig. 3.

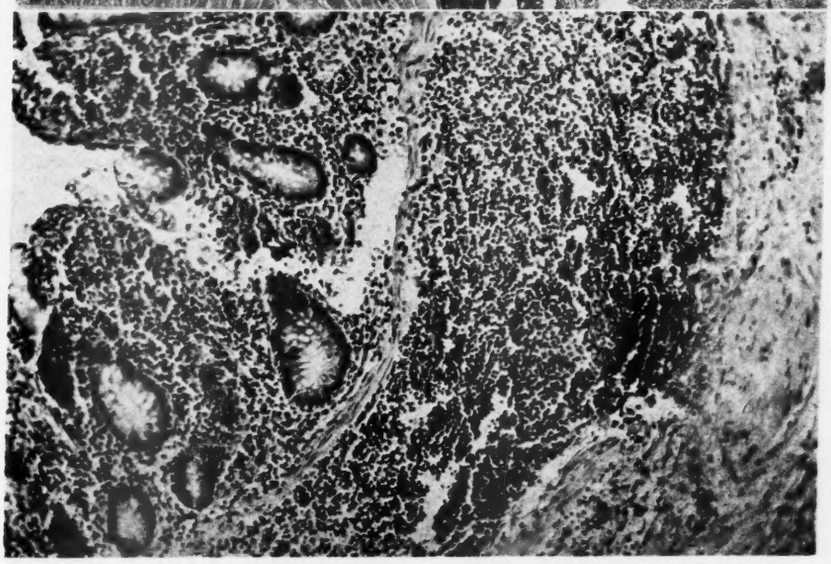

Fig. 4.

Fig. 3. Showing the continuation of layers of appendix over its diverticulum.
Fig. 4. The subacute inflammatory reaction of the mucosa, submucosa and muscularis is illustrated.

The white blood cell count was 6,800 per cc. with 72 per cent polymorphonuclears. The red blood cell count was 3,980,000 and the hemoglobin 80 per cent. The urinalysis and Kahn tests were negative.

A tentative diagnosis of subacute mesenteric lymphadenitis was made and the patient was permitted to return home under observation and conservative treatment consisting of rest, bland diet, and the administration of mineral oil, 1 ounce twice a day was ordered.

wall of the terminal ileum was normal and several enlarged lymph nodes were found in its mesentery. There was no Meckel's diverticulum or visible diverticula of the cecum and transverse colon. The wound was then closed in layers without drainage and the patient was returned to her room in good condition.

The postoperative course was uneventful and the operative wound healed per primam. On September 23rd she was discharged from the hospital without complaint.

The specimen consisted of the appendix and its attached mesentery. Multiple diverticula involved the wall of the appendix and mesentery, and two of these were edematous, red, and obviously inflamed. Longitudinal section demonstrated that the lumen of the diverticula communicated freely with that of the appendix. (Fig. 2.)

Microscopic examination showed that all layers of the appendiceal wall were continued over the diverticula. (Fig. 3.) A marked lymphocytic and polymorphonuclear leucocytic infiltration was present in the mucosa, submucosa and muscularis of two of the diverticula. (Fig. 4.) On the basis of these findings, a pathologic diagnosis was made of diverticulosis of the appendix with superimposed subacute inflammation.

## COMMENT

Diverticula of the intestinal tract are most commonly found in the large bowel, particularly the descending and sigmoid colon, and occasionally in the small intestine. In the colon they usually adjoin the appendices epiploicae and are of the false acquired type which frequently gives rise to symptoms. In the small bowel they are almost invariably situated along the mesenteric border and seldom produce symptoms. Diverticula of the vermiform appendix, however, must be exceedingly rare since we have been unable to learn of any recorded or unrecorded case similar to the one described. The appendiceal diverticula in this case unquestionably were of the true congenital type with superimposed subacute inflammation.

# RECONSTRUCTION OF THE COMMON DUCT WITH VITALLIUM TUBES

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SINCE the introduction of the vitallium tube by Dr. Pearse, of Rochester, New York, many cases have been reported in the literature in which the reconstruction was facilitated by the use of this type of a tube. Dr. Frank Lahey has raised the problem concerning the pressure caused on the neighboring blood vessels by such a tube and wondered if it would not be wiser to continue the use of rubber tubing. This is a legitimate question and can be answered only by following a large series of cases for years.

The following case is reported so that it may be included in this series as well as to point out some unusual experiences such as: (1) The accidental and fortunate establishment of an abdominal biliary fistula by surgery just at the time that the patient was on the verge of establishing his own bronchobiliary fistula; (2) the necessity for having many types of vitallium tubes ready on the operating floor; (3) the establishment of a gastrohepatic biliary fistula with rubber tubes which was blocked by the rotting away of one of the rubber tubes, and (4) the successful re-establishment of the normal connection between the two hepatic ducts and the distal end of the common duct with the aid of a "Y" shaped vitallium tube.

## CASE REPORT

Mr. A. R. was admitted to the Rhode Island Hospital on July 24, 1942, because of persistent, intense, painless jaundice. The past history revealed that he had had a cholecystectomy in another hospital in this city in December, 1941. Following the operation the patient had been well for three days. Then a large amount of brownish fluid drained through the incision. This drainage continued to be profuse for several weeks and then decreased in amount. With the decrease and finally the disappearance of the drainage, jaundice, clay-colored stools and a severe itch set in. *X*-rays were taken and he was referred to the Tumor Clinic. It was decided at that hospital, according to the patient, that nothing else could be done. The patient was discharged. The jaundice increased in severity until the patient "looked like a Chinese." His appetite had been poor. Stools continued to be clay-colored and there had been a loss of twenty-five pounds in weight as well as a sapping of his strength and energy. On his doctor's recommendation he had several carious teeth extracted.

The physical examination on admission to the Rhode Island Hospital seven months after his cholecystectomy showed a thin undernourished ambulatory man of thirty-three; weight 105 pounds; blood pressure 94/65. icteric index 84; Van den Bergh immediate direct; hemoglobin 11 Gm.; red blood count 3,600,000; feces negative for bile; urine 4+ for bile. His temperature was 99°F., pulse 100, respirations 20. Except for a well healed upper right rectus scar and jaundice the physical examination was negative.

The prothrombin time was reported as 106 per cent of normal but the intern made a note that he must have made some mistake. *X*-rays showed no evidence of disease in the heart, lungs or upper abdomen.

The patient was prepared for surgery with vitamin K, high carbohydrate, high vitamin diet, etc., with the expectancy that he had one of the three following conditions: (1) injury to the common duct, (2) stone in the common duct, or (3) carcinoma of the head of the pancreas.

The operative note made on July 29, 1942, the day of the operation follows:

Preoperative Diagnosis: ? Injury to common duct or stone in common duct.

Operation Performed: Exploration of common duct.

Postoperative Diagnosis: Injury to common duct.

A right rectus muscle-splitting incision was made. On opening the peritoneum, numerous, dense adhesions of the omentum to the under-

FIG. 1. Photograph of *x*-ray following second operation. Only one of the rubber tubes could be visualized by *x*-ray.

surface of the liver were found. These were freed by sharp dissection. Bleeders were tied. The liver edge was round and the liver appeared slightly enlarged.

The common duct area was exposed and the foramen of Winslow identified. A thickened, normal-sized common duct was isolated. Two silk retraction sutures were placed in it and the duct opened. A probe was inserted down into the duodenum with no difficulty. The probe was then directed upward and found to meet an obstruction. The common duct was further dissected and a small stump, apparently the remains of the cystic duct, was identified. About one-quarter inch above this, the common duct terminated. Exploration failed to reveal any evidence of the upper portion of the common duct or common hepatic duct. The portal vein and hepatic artery were dissected free from surrounding tissue so that all structures in this area were definitely identified.

A needle was inserted into many suspicious areas but no bile was obtained from any of them. The upper end of the remains of the common duct was rounded, so that there was no question that this was the upper end. The needle was inserted into several areas in the liver in the hope of establishing a biliary fistula.

The head of the pancreas, stomach and duodenum appeared normal. The patient's condition was poor and the search for the upper end of the common duct had to be stopped after three hours and twenty minutes of operating.

A cigarette drain was inserted down to the foramen of Winslow and the wound closed in layers about the drain, using No. 00 chromic double continuous catgut in the peritoneum, single of the same in the muscle, chromic No. 0 figure-of-eight in the fascia. Four stay sutures were used and one cigarette drain inserted.

Discussion of this operation lead us to believe that the upper half of the common duct had been injured and that what was left had shriveled up so that the hepatic ducts were now intrahepatic. Moreover, my failure to locate the site had robbed this individual of his only chance to survive. Postoperatively,

the temperature spiked to 101°F. for about eighteen days. During the first eleven days the wound appeared clean and dry. There was no pus cells, many bacteria, occasional pigment granule and rare crystal resembling cholesterol. Culture revealed many Gram-negative rods of

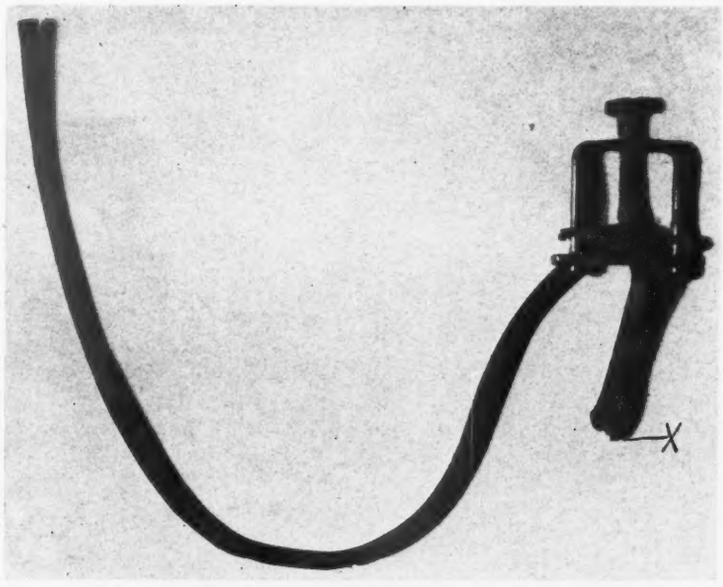


Fig. 2. Shows catheters removed. Note short tube pointing downward. It rotted away at x.

sign of bile. The sutures and drains were removed. Our wound had healed well and we attributed the temperature to a "hepatitis." On the twelfth postoperative day bile was seen on the dressing. A rubber catheter was inserted into the sinus and continuous suction was applied in the hopes of encouraging the flow of bile. Fortunately this happened and whenever there was a tendency for the sinus to contract down, dilatation was carried out.

The icteric index on August 1, 1942, three days postoperatively, rose to 96. On August 17, 1942, nineteen days postoperatively and five days after the appearance of bile on the abdominal dressing, it had dropped to eighteen and remained therabouts.

From the eighteenth to the forty-first postoperative day the temperature remained within normal limits. The patient's general condition improved and his own bile was fed to him in grape juice.

From the forty-second to the fifty-third postoperative days the patient had repeated chills with a rise in temperature to 104°F. The white blood count averaged about 17,000 with a fairly normal differential. Blood cultures were sterile. The bile, however, which had formerly been clear became muddy in appearance. Microscopic examination showed a number of the colon group, Streptococcus non-hemoliticus, Bacillus pyocyaneus, aerogenes and Proteus morgani. Sulfadiazine was started with an initial dose of 3 Gm. and then 1 Gm. three times a day. We probably should have given more but were afraid to. The blood level ranged around 5 mg. per cent for the free and 8 mg. per cent for the combined. The last chill occurred on the sixty-fifth hospital day. From that day until his second operation the temperature remained normal. The patient, however, lost all of the ground that he had gained. He refused to take his bile even by gavage. His weight came down to 97 pounds. The serum protein was reduced to 5.8, hemoglobin 12.8; red blood count 3,750,000; cholesterol 202; icteric index 20; urine essentially normal. Three blood transfusions were given.

It was decided that something had to be done in order to get the bile draining into the gastrointestinal tract.

In view of the fact that the common duct was believed to be intrahepatic it was thought best either to dissect out the sinus and implant it into the stomach or small bowel or else to re-establish the connection of the biliary and gastrointestinal systems with a vitallium tube. A special tube was ordered with four holes bored into the widest end. It was hoped that

this could be sutured to the liver at the liver end of the biliary sinus and the smaller end would either be inserted into the distal half of the common duct or into the small bowel. This foramen of Winslow was closed off and all the tissues in front of it were markedly edematous. Identification of the individual structures was impossible.

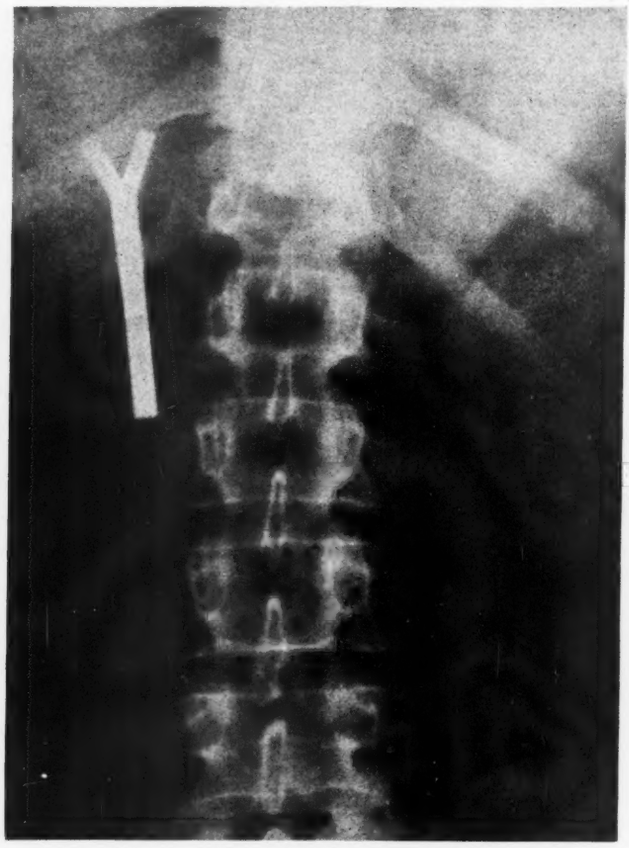

FIG. 3. Shows Y-vitallium tube in place eight months postoperatively. Dense shadow in middle of stem of tube represents point of union of two tubes to give added length required in this case.

was the only vitallium tube which we had. The operative note follows:

Preoperative Diagnosis: Old common duct injury.

Operation Performed: Hepaticogastrostomy.

Postoperative Diagnosis: Same.

The abdomen was opened through an old right rectus scar. The biliary fistula was excised and was traced down to the right lateral wall and found to extend between this wall and the liver. The fistulous tract apparently led over the upper surface of the liver and not into the remnants of the common duct as was expected.

As soon as this was realized, this dissection was left alone and the undersurface of the liver was explored just above the foramen of Winslow. There were considerable dense adhesions of the omentum and duodenum. The

After considerable searching, a nubbing was encountered which appeared to be the upper end of the common hepatic duct. The tissue about this was very dense. It had to be incised with a knife. As this was done, a dirty, whitish, mucoid bile gushed out so fast that suction alone could not keep ahead of it. As soon as the bile had stopped flowing, the region was further explored. A culture of this bile was taken.

It was found to be just at the bifurcation of the hepatic ducts and the septum between the two hepatic ducts could be seen. The septum was incised in order to make it possible to put in the vitallium tube, but this was not enough as the amount of hepatic duct wall was very small. The vitallium tube was placed into the right hepatic duct using the straight, narrow end. It was sewed in place with difficulty but was quite firm when this was finished. A No. 12

French catheter, the end of which was cut, was then inserted in the left hepatic duct and sutured. This field was then walled off and the duodenum was identified. It was rolled out and the remnants of the distal common duct was found. A French clamp was placed into it and then found to go into the second portion of the duodenum. Another clamp was placed in the same opening, and it was found that it went directly posteriorly in toward the head of the pancreas.

Study and discussion ended in assuming that in this patient, the duct of Wirsung entered the common duct just before the common duct entered into the sphincter of Oddi. An attempt was made to bring this portion of the common duct up to the metal tube so that at least half of the liver would drain into the duodenum. This was found to be impossible as the gap was too great. Attempts to mobilize the duodenum were unsuccessful because of the profuse bleeding that was encountered. The duodenum itself could not be brought up to the metal tube without there being too much tension. In desperation, a small rubber catheter was placed through the metal tube into the right lobe of the liver and sutured to the four small openings which had been made in the end of the metal tube. These two catheters were then brought out over the stomach and the omentum above the stomach was lapped around them.

An opening was made into the stomach and a hole was made in each of the two catheters at this point. The catheters were then sutured so that the bile would empty into the stomach and the stomach wall was sutured over the two catheters in the hopes that a biliary fistula from the hepatic ducts to the stomach would be established. The open ends of the catheters were then brought out through the greater omentum, and the greater omentum sutured to the openings in the stomach and the catheters were brought outside the abdominal wall.

A rubber tissue drain was placed down to Morrison's pouch. The wound was closed in layers using four through-and-through heavy silk stay sutures. Continuous No. 00 chromic catgut sutures were placed in the peritoneum, and interrupted No. 0 chromic in the fascia.

Interrupted silk was used for the skin.

The operative time was close to five hours and needless to say the patient's condition was poor. We persevered because we realized that this was the only chance which the patient had to survive.

Several interesting observations results from this procedure: (1) That at the time of the first operation this patient was apparently on the verge of breaking through the dome of his liver and establishing his own biliary drainage. It is quite probable that this would have developed into a bronchobiliary fistula and that our fortunate and timely interference provided the bile with an easier exit. This must have occurred on the twelfth postoperative day. The continuous suction likewise encouraged the development of this tract. (2) The swelling of the liver made the hepatic ducts intrahepatic at the first operation and the "deflation" of the liver associated with the drainage of bile made enough of the ducts extrahepatic so that we could see them at the second operation. (3) The various types of vitallium tubes should always be available at these operations as one can never tell what condition is present. (Fig. 1.)

Seven days following the second operation the icteric index rose to 35. On the fourteenth day it was 19, on the twentieth it was fourteen and on the twenty-ninth day it was 9 with a cholesterol of 268. The postoperative convalescence was unusually smooth. The temperature never rising above 100.5°F. and returning to normal on the eighth day postoperatively.

Drainage from the wound was moderate and ceased on the tenth day. Healing was excellent. The rubber catheters were unclamped only for pain and this occurred but twice.

The reason for bringing the tubes out through the abdominal wall may not appeal to some but it seemed to us to offer two advantages: First, that suction could be applied even though there was an opening into the stomach and secondly it might be possible to remove the tubes after a long interval had established a firm sinus, without submitting the patient to further surgery.

The patient was discharged with normal-colored stools 123 days after admission, 117 days after his first operation and thirty days following his second operation.

One month after discharge he weighed 135 pounds which was his normal weight.

On March 24, 1943, the patient was readmitted because of a vomiting spell and fear that something had gone wrong. He remained in the hospital for five days. The vomiting did

not recur. The feces were brown in color. Laboratory work showed: Hemoglobin 16.1; red blood count 4,570,000; white blood count 12,850; Van den Bergh direct reaction; icteric index 6; urea nitrogen 9; cholesterol 272; glucose 83; total protein 7; urine (normal) no bile present.

On July 11, 1943, the patient was readmitted because of epigastric pain which was referred to the right shoulder and jaundice. The temperature, pulse and respirations were normal on admission. Examination showed: Icteric index 18; Van den Bergh immediate direct reaction; white blood count 13,450; hemoglobin 14; red blood count 3,820,000.

The stools intermittently showed absence of bile. The temperature showed some fluctuation and the icteric index rose to 44 on the twenty-eighth hospital day. On the very next day the temperature returned to normal, the patient felt better and his icteric index gradually improved until it reached 17 on the thirty-third day since admission.

During this hospital stay it was realized that a "Y" vitallium tube would have to be inserted in place of our makeshift combination. A tube one and one-half times the usual length was ordered and had not arrived, so that the patient was discharged.

The patient was readmitted on August 23, 1943, because one of the rubber tubes had broken in half. Our vitallium tube had arrived earlier but the patient was getting around quite well and desired to postpone his operation as long as possible. We agreed, but this accident gave us the opportunity for attempting to insert our vitallium tube.

The laboratory work follows: red blood count 4,560,000; white blood count 17,450; hemoglobin 13.9; blood urea nitrogen 10; glucose 94; total protein 6.5; sodium chloride 468; icteric index 21; Van den Bergh immediate direct; urine ? bile; stools varying color but never clay-colored.

Operation was performed on August 27, 1943. The operative note follows:

Preoperative Diagnosis: Absence of the common duct due to trauma during cholecystectomy.

Operation Performed: Reconstruction of the common hepatic and common duct.

Postoperative Diagnosis: Same.

The abdomen was opened through the old right rectus scar. Dense, firm adhesions were found throughout. The stomach was adherent to the undersurface of the peritoneum. An elliptical incision was made in the peritoneum and then around the stomach at this point. A tie was placed to close the mucosa which was not opened. Interrupted sutures were used in the muscularis and serosa of the stomach and reinforcing the first layer. The stomach and duodenum were firmly adherent to the undersurface of the liver. These organs were separated by blunt and sharp dissection so that finally the foramen of Winslow could be identified.

The finger was introduced into this foramen and the metal tube could barely be palpated. There was a great deal of thick, fibrous tissue where the common duct should have been and where the sinus probably was. This fibrous tissue was carefully dissected away from the right side toward the midline. The hepatic artery could be seen pulsating. An incision was made parallel and to the right of it in the peritoneum and fibrous tissue. This vessel was gently retracted toward the midline. The portal vein could not be identified at any point during the operation. The incision in the fibrous tissue sinus tract was carried down toward the metal tube. The end of the tube was uncovered and it was found to be firmly fixed in the liver substance. The ties which had been placed in the tube to hold it in position were finally seen and cut and the tube was easily removed. It was known that this tube was in the right hepatic duct. Careful dissection opened the left hepatic duct. A Kelly clamp could be placed in each one and it was definitely noted that the left hepatic duct extended toward the left and the right toward the right. The Kelly clamp could be inserted for quite a distance. The duodenum was rolled down exposing its posterior portion. The silk suture which had been placed on the distal end of the common duct was found and it was traced down to the common duct. This was freed and a definite wall lining the inside of the duct could be identified. The Kelly clamp inserted through this opening was found to enter into the duodenum. A possibility of this being the sinus tract opening was thus ruled out. The "Y" vitallium tube was then placed in position so that each limb of the "Y" entered into one of the hepatic ducts and the open end was inserted into the common duct.

A suture was placed through the opening provided in the tube. The tube was sutured to

the undersurface of the liver. Another suture was placed through the same opening and used to anchor the tube to the duodenum. Whatever tissue that was present was then used to make a covering for the tube so that a sinus tract could be established. The cigarette drain was placed toward the foramen of Winslow after 5 Gm. microcrystals of sulfathiazole had been placed in the peritoneal cavity and over the liver.

The wound was closed about the drain using No. 00 chromic doubled continuous to the peritoneum, four heavy No. 4 stay sutures through-and-through the abdominal wall, interrupted doubled No. 60 cotton in the fascia and interrupted cotton in the skin.

The surface of the liver was found adherent to the undersurface of the diaphragm. These adhesions were quite firm and were not disturbed. When the hepatic ducts were opened greenish bile containing some mucus had to be removed by suction. The patient was given a transfusion as well as intravenous fluids throughout the operation and he left the operating table in excellent condition.

Postoperatively there was considerable drainage of bile from the abdominal wound. The stools became clay-colored and the urine contained bile. The icteric index rose to 36. Temperature remained normal after the second postoperative day.

On the twelfth postoperative day the icteric index dropped to 17. Several days previously bile had been seen in the stool but the abdominal wound was still draining bile profusely. This gradually diminished and disappeared at the time of discharge. The icteric index was 11 on the twenty-second postoperative day when the patient was discharged with the bile flowing freely into the gastrointestinal tract.

Since his discharge and up to the present, a period of approximately twenty-four months this patient has remained well. There have been no recurrent attacks of chills, fever, malaise, etc., which are associated with ascending infection of the liver from the gastrointestinal tract and it is quite possible that these will not occur because the distal end of the common duct was used and the sphincter of Oddi will prevent infection from ascending to the liver through the vitallium tube. The patient has been free from pain and the icteric index has returned to normal. He has also returned to his former occupation. (Figs. 2 and 3.)

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# Bookshelf Browsing

## PRE-COLUMBIAN MIDDLE AMERICA MEDICINE

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THE American Indians from the north as far as the Dakotas to the south as far as the lower borders of Chile, had entered upon advanced stages of social and cultural development long before the land of the Americas was discovered by Columbus and his followers. However, it is difficult for the historian of the present to unravel the story which must have been presented to one, who in the early colonial period, would visit these ancient races in their native homes and villages. In but a few instances have definite pictorial records of their daily existence been handed down by these people. Even in our own country of the United States with its backward native civilization, the mound builders evidently had reached a high grade of a crude civilization centuries before the white man came. Because of absence of a written language, it is only by piecing together here and there objects found in these mounds that it is possible in a hazy and unsatisfying manner to form a concept of what the daily life of these early people might have been.

However, as we go farther south into Mexico and Central America and beyond into the Highlands of Bolivia, Peru and Ecquador, we find more permanent ruins and fairly well preserved archeological structures which indicate to us that a high culture had existed in this region centuries before Columbus came. The temples of the Toltecs, Zapatecs, Chimus, Incas, and the Mayas built of enduring stone indicate the high plane of civilization attained by these ancient peoples. We know that the Aztecs and those who preceded them, the Toltecs, and even before that, the more ancient people called the Archaic race, had developed the arts of peace as well as those of war to a high degree. We also know that the Incas of Peru and the preceding race, the Chimu, were of high intelligence and great ability. As they gradually learned to produce the architectural wonders which even in their ruins astound us, we must give them credit for having been advanced in other fields of human endeavor. The conclusion is impressed upon us that many generations of thinkers must have brought to these intelligent peoples some ideas of the causes of disease, and the experiences gained in their contemplative philosophy must have aided them in developing a system of therapy by which they sought to cure or to remove the ills to which their bodies were subjected. However, since they were not acquainted with the physical make-up of their body and only knew in a hazy manner a few of its functions, they were engulfed in a sea of uncertainty and ignorance. Out of this void of uncertainty by sheer intellectual effort, contemplative study, and comparative deduction, they groped their way to their own metaphysical interpretations of the phenomena of disease. Naturally their conclusions were full of distortion and error. As a corollary of an existence which was full of terror, uncertainty and dread, they associated the many ills of the body with the activities of demons or of evil spirits who had entered into and took possession

of it. By holding to such a philosophy it is easy to understand how the cult of the priest and that of the physician in time became almost indistinguishably welded.

The priest was supposed to understand the habits, languages and motives of the spirit world and was regarded as competent by the exercise of exorcism and magic to remove unwelcome visitors of the spirit and demon world who, entering into the body, had caused its suffering and disease. When the processes of exorcism became too involved and complicated, specialism took place in the ranks of the priesthood. Especially was this so in the Americas among the Mayas. Gradually a group of the priesthood assumed as their own particular perogative the practice of the healing arts and the care of the sick and injured. The members of this specialized group were called Shamen. It is interesting to note that the term Shaman was generally used among primitive people over almost the entire world to designate the type of individual who was entrusted with a combination of ecclesiastical and medical duties. We find that the priestly doctors were called Shamen in far northern Siberia, in the Alaskas, among the Polynesians and the early Egyptians. We also find the term is used to designate a form of minor priesthood in the Hebrew religion where the shaman has somewhat the same standing as the elders in the Presbyterian church. The traveler in South America and in certain parts of Central America, especially in the Highlands of Guatemala, will find that where the customs are still primitive and Catholic priests are unavailable, the party or person who takes the place of the priest is called a shaman. It would be an interesting diversion to dwell upon the universal and wide use of this term as an indicator of the common ancestry of certain components of the human race and to speculate upon the interrelation of various tribes and peoples.

Among the American Indians the shaman also had a place of high respect for we find that in the early Indian religion that the shaman was entrusted with special duties and had assumed definite obligations. Among the Mayas and the Toltecs, one of the duties of the medicine man or priest-physician was to administer at the religious services to the serpent god.

We know that folk customs and practices are particularly tenacious and are hard to change since they have sunk deep into the very roots of racial existence so that even in this enlightened day we find that a type of serpent worship still persists in widely separated regions. This worship is serviced by particular and specialized ceremonies as illustrated by the serpent dances of the Hopi Indians, by whom the serpent is regarded almost with veneration. We even find in the legends of the early Hebrew and Christian religions that at times the serpent was held in a venerated or deified position and even as a repositor of wisdom was accused of having tempted Eve to seek forbidden knowledge by eating of the apple. In this manner the serpent in his evil power was associated with the downfall of man.

We may permit speculation as to the reasons why the serpent had acquired such a hold upon the imagination and philosophy of primitive man. It is likely that his reverence for the serpent and his belief of its association with occult power and lethal influence might to some extent be explained by the mystery of its mode of existence, its silent and unexpected appearance from the recesses of the forest with its graceful forward movement without legs, its very long life which seemed to partake of life everlasting, the periodical casting off of its skin by which it was thought to reincarnate itself, its long disappearance into the depths of the ground where it apparently became associated with the demon gods of the nether world, and its ability to kill with the poison generated in its own body. All of these fired the primitive imagination which clothed the serpent with supernatural powers. As the most important of these many attributes the serpent was thought to have

knowledge of good and evil. He was regarded as a teacher of wisdom and a prognosticator of future events and as the dispenser of health to those whom he condescended to aid. The latter attribute or power probably explains the association of the serpent with the healing art.

It is also easy to understand how in early anthology this worship with its sinister implications could become the embodiment of all that was evil. Because of the stealthy approach of the serpent and its unannounced presence it became an object of fear and dread. As a consequence, effort was made to appease it, and in the course of time it was elevated to the rank of a deity. As man's ability to live and survive depends upon the vigor of his body and his freedom from destructive disease and crippling accidents, it is not surprising that he sought to appease and propitiate this serpent god who was so potent for good or for evil.

In consonance with the tendencies of other races of the world it is not surprising that the American Indians, especially the Toltecs and Mayas, developed a well defined cult of medicine and that this was associated with the worship of the serpent god. The priests of this cult were regarded as skilled in the arts of healing the sick and in the treatment of wounds. This reputation was well merited because in the course of many generations they had accumulated a considerable fund of knowledge and were expert in the treatment of disease. As is usual with all groups who possess special skill, they finally organized themselves into a kind of brotherhood which required that novitiates be scrupulously selected both for intelligence and natural ability, and that after selection they be put through a rigid course of instruction and training. It is significant of a constantly increasing restrictive tendency that among the Aztecs and the Nahuas of ancient Mexico the medical priesthood was hereditary and descended from father to son, from generation to generation. This same procedure was noted in Chile by Ovallie whose observations were made in 1649. Education was under the father's guidance and in Mexico opportunity for practice in the public hospitals was given. There was also free access to the botanical gardens. Anatomical knowledge was advanced by dissection of the bodies of the persons killed during sacrificial ceremonies.

The Maya Indians regarded the medicine man with great reverence and respect and designated selected boys at an early age for this high calling at the age of ten or twelve years. Boys destined for the priesthood were selected because of their natural inclination and their peculiar aptitude and intelligence. They were required to have a strong pulse and a healthy body. After selection they were segregated into special schools where they were instructed in the obligations and duties of their high office. They agreed to remain in celibacy for twenty years and had to respond to all calls of the sick and afflicted. For at least a period of their instruction they were confined in solitary buildings where they dwelt in company with their instructors. For the first two years they were subjected to severe discipline. They must not eat flesh nor anything having life, but live solely on vegetables, drink only water and not indulge in sexual intercourse. During the probationary term neither parents nor friends were permitted to see them. At night only were they visited by professional masters who instructed them in the mysteries of necromantic art.

Among other Indian tribes it was required that a young man desiring to become a medicine man would first have to find a competent teacher who was willing to accept him as a student. After a prescribed period of training both teacher and student apprentice retired to a hut in the forest where the novice was instructed in the more intimate ceremonials and the incantations and medical practices required of the medicine man for proper functioning of his art in the treatment and cure of

disease. When the period of instruction was completed the apprentice was left alone in the hut and was then supposed to encounter a serpent (boa-constrictor), which reared up and placed his tongue in the mouth of the young man and transferred to him the wisdom of his calling. In this way the initiation was completed. Among some of the Maya tribes three novices were assembled at one time and at the end of the investment ceremony each of the novices was supposed to be devoured by a snake and was later expelled through the anus. In his passage through the snake, the novice was supposed to acquire the knowledge of various herbs and drugs and medical practices.

After his education was completed the neophyte entered upon the practice of his profession and was granted the privilege of wearing the insignia of the medicine man. In some tribes, as the Wabeno tribe of North American Indians, (Schoolcraft, H. H.), a musci scroll of medical or magical significance was given to the student on completion of his course of training. From the presenting symptoms he made his diagnosis and prescribed his treatment. Empirical diagnosis based upon symptoms was not always easy and in some cases required considerable intelligence of a high type.*

The medicine man not only prepared the medicine which he used but he frequently administered it. This was accompanied by proper ceremonial incantations and ritualistic formulas by which such assurance was conveyed to the patient that he became convinced of the authoritative source of the methods used in his treatment. Incantations were also used to qualify the diagnosis and to indicate the proper drugs and practices to be used in treatment. They also were the means of determining the prognosis of the particular condition from which the patient was suffering. In the medical seances the rapport or sympathetic relationship between patient and medicine man was very considerable. By the hypnotism of his calling the medicine man had become convinced of his own power and was acting in most cases in entire harmony with both his patient and his art, so that the patient imbued with the confidence displayed by the medicine man, did not doubt his ability to bring him into contact with the spiritual world through which he would obtain relief. As an aid to this state of mutual accord a mild intoxication was induced in both medicine man and patient by the administration of narcotics or by the drinking of intoxicating liquors. The Datura or ginsen weed of the southwest, or tobacco which was indigenous in all the Americas, was frequently used. A state of half consciousness was induced; in this trance-like state hazy and half formed visions would materialize. These visions embodied the ideas and conclusions suggested by the medicine man. Also certain things which the patient was to avoid and which were to be taboo were suggested to him in his narcotic semi-consciousness.

The members of the tribe usually had great respect and reverence for the medicine man who usually was of outstanding personality and shrewd intelligence and carried himself with great dignity. By his skill and cunning he was able to deceive the simple minded members of his tribe. He impressed them with the magnitude of his powers and developed a position of respect and prestige for himself and his art. This was very necessary for his success because the medicine man was held to be particularly qualified to treat disease because of his intimate contact with the spirits of his ancestors. Also he was thought to be in communion with the gods who were represented in the various birds, quadrupeds and reptiles whom he had encountered in his journey through life. From them he was supposed to have learned many intimate qualities of life's mysteries.

* Bancroft, H. H. Native Races of the Pacific of North America. New York, 1875–1876. D. Appleton & Company.

By his superior knowledge of the elements he was credited with the ability to see into the future and was regarded as qualified to predict changes in the continuance of an individual's health and the onset of disease. In difficult cases he was supposed to see and hear the spirit of the patient and thereby was able to understand better the spiritual and physical conflicts occurring in the patient. From this knowledge he was considered as capable of prognosticating the course of the disease and the prospects for recovery. The medicine man not only impressed his followers with his ability in the healing arts and in the cure of human ills, but also with his general superiority in all lines of endeavor.

In the treatment of disease his methods may be formulated into (1) the rituals and mysteries of sorcery, (2) incantations and mummeries of magic, (3) in his more material therapeutics he made use of organic substances, animal or vegetable, and inorganic substances, minerals, etc., (4) manipulative procedures, (5) physical measures as baths, blood-letting, etc., and (6) surgical procedures.

In the practice of sorcery and magic, incantation usually was associated with dancing which was regarded as a necessary part of the procedure. This dancing consisted of strenuous movements of a ceremonial character with a shuffling two step and a third step in between, by which the entire movement was exaggerated. The dance was accompanied by a chant; both dance and chant were of almost interminable duration, so that they frequently were terminated by the medicine man and his acolytes falling down unconscious from exhaustion.

An example of the procedure of medical divination as practiced among the ancient Mexicans is given by Nuttall as follows: "When someone was ill they called the medicine woman or man in order to ascertain how the illness would end, and placed an idol in front of the patient. This idol was named Quetzalcoatl, or 'Plumed serpent.' On entering the house permission was asked of the household god. A demijohn of balche, an intoxicating liquor, was received and during the procedure the shaman kept himself goodly intoxicated, according to Meetal.* A mat was laid upon the floor and the medicine man or woman sat on this and in front spread a white cotton cloth. The shaman then took twenty grains of maize in his hand and cast them upon the white cloth, just as the Spaniards cast dice. If the said grains fell in a circle, leaving an empty space in the center, it was a sign that the patient would die of his illness and would be buried, the empty space being regarded as the sign for a grave. If the grains fell on top of each other, it signified that the illness had been caused by sorcery or witchcraft, but if in falling the grains divided into two parts, one half being on one side and one on the other, so that a straight line could be drawn through the middle of the group without touching a single grain, it was a sign that the disease would leave the patient and that he would recover."†

Types of sorcery and magic somewhat similar to that of other ancient days are at present being practiced among the descendants of the Mayas, by individuals who combine the functions of priest, sorcerer and physician. These "yerbateros" of today are called Ah-men by Roy's and H'men by Starr.

"These on occasion might undertake to cure disease or to provide a love potion." (Shattuck quoting Roy's—Roy's 1931 Ethno Botany of the Mayas quoted by Shattuck, George C. The Peninsula of Yucatan, 1933, P. 64, pub. Carnegie Inst. Washington, D.C.

In more materialistic application of the therapeutic art are to be grouped methods of the Maya and the ancient Nahuas who lived in what is now Mexico. They, like all other peoples, subscribed to the prin-

* Meetal, B. T. Medicine in Ancient America. *Hygeia*, 13: 343, 1935.

† Sorcery, Medicine and Surgery in Ancient Mexico, by Nuttall, Z. *Jobns Hopkins Hosp. Bull.*, April, 1902.

ciple that "like cures like." So it happened that many Indian tribes, the Mayas in particular, treated a disease with objects which would produce changes similar to those present in the disease, such as the application of crushed wasps nests or other stinging insects for skin eruptions or the decoction of yellow plants for jaundice. (Ciba Symposia; 1: 13, 1939.)

In the more material concept of disease as being due to disturbances of the structures of the body and in his rationalization of methods of treatment of disease, some tribes of the early American Indians, especially the Mayas and the Aztecs were as far advanced, if not farther, at least in some respects than the contemporaneous Europeans. This was confirmed by the Spaniards who noted that Indian medicine was far advanced and they marveled at its sufficiency. Such a high proficiency is quite conceivable, because it is understandable how an intelligent but primitive people can marshall observations and formulate them into conclusions from which concepts of astounding accuracy may be deducted. These crude concepts of the early Indian medicine men are startling in their similarity to those which were later formulated by trained observers who had at hand a wealth of scientific data. It is therefore, not surprising that the medical and therapeutic methods and procedures of the Aztecs and Mayas were rich in innovation and qualified achievement, though they were entirely different and at times were at variance yet in some respects were far in advance of the practices of the civilization of the old world. For instance, their method of treating wounds was an example of their advanced technic in that they coaptated the edges of an incised wound with hair sutures. After closure, the wound was bathed with the juice of the agave plant. However, if the wound had healed badly and had left an ugly mark, it was reopened and was cauterized. It was again sewed with hair and covered with melted ulii which is the juice of the India rubber plant.

In the treatment of disease the Indian used herbs, roots, leaves or twigs, occasionally seed flowers. Animal substances, insects, earth and minerals were also included in the therapeutic armamentarium. From these substances extracts and infusions, powders and concoctions were made. These were given to the patient to drink or were applied to the surface of the body. Indian medicine men were acquainted with and used preparation of narcotics, sedatives, purgatives, emetics and stimulants. They used hemastatic substances to control bleeding and applied healing and cleansing solutions for wounds. They also were acquainted with physical methods of treatment such as massage, scarification, venesection, counter-irritation, bandaging, poulticing, tooth pulling, cupping and sucking. They were able to set fractures and apply splints. They also applied manipulation by pressure and controlled hemorrhage by tourniquet. They also used cauterization. Some of these practices were based upon observation but many, however, were thought by the Indians to be the result of a supposed mystic and supernatural directional guidance obtained by the medicine man from the spirit world. It is interesting to know that the American Indian used fifty-nine drugs which are now included in modern pharmacopeias.*

Drug preparations which have been found valuable, and are now in universal use, were indigenous among many Indian tribes and were originally used by the Indians are: canabis indica, cascara sagrada, chaparro, chenopodium, condurango, cocoa, copal, guiac, hualtata, hydrastis, ipecac, jaborandi, jalap, krameria, mandragora (I believe this was already known in Asia Minor), peruvian balsam, sabadilla, sarsaparilla, and tolu balsam. In addition to their medical practice, Indians were accustomed to embalm and to cremate. Isolation was used in the treatment of cer-

* Stone Age Medicine among the American Indian. New York, 1932. Hoeferm, Quoted from Ciba Symposia, W. M. Grogman, 1:11, April, 1939.

tain infectious fevers. Drugs were sold in open markets in special areas of these markets. To supply one of such markets the emperor Montezuma had established a botanical garden in which practically all the drugs used by the medicine men of his realm were grown. This garden was very extensive. Most of the three thousand plants used by the Mexican Indians in the treatment of disease were cultivated. Strange to say, these early Indians had rubber syringes which they used for giving enemas. Circumcision was also practiced. They also used flowers of datura stramonium, the so-called jimson weed, to produce twilight sleep.

The present day Indians of this continent may well be proud of their pre-Columbian ancestors who along with their other arts and sciences, especially astronomy, developed medicine to a remarkable degree. In the present article it is impossible to consider in more detail the diseases of the Indians, the physical deformities from which they suffered, also the detailed methods of treatment which were in use especially by drugs and other means. It is interesting to know that hospitals had been erected by the Aztecs long before the coming of the Spaniards and that in some areas the infectious diseases which they had learned could be communicated from one to another were segregated in special areas and buildings.

It will also be interesting to compare the treatment practiced at the time of the conquest with that prevalent in Europe, and to learn how many methods, innovations, and improvements in practice were introduced into European medicine from the suggestions obtained by the Spaniards from the great Indian races of the western hemisphere.

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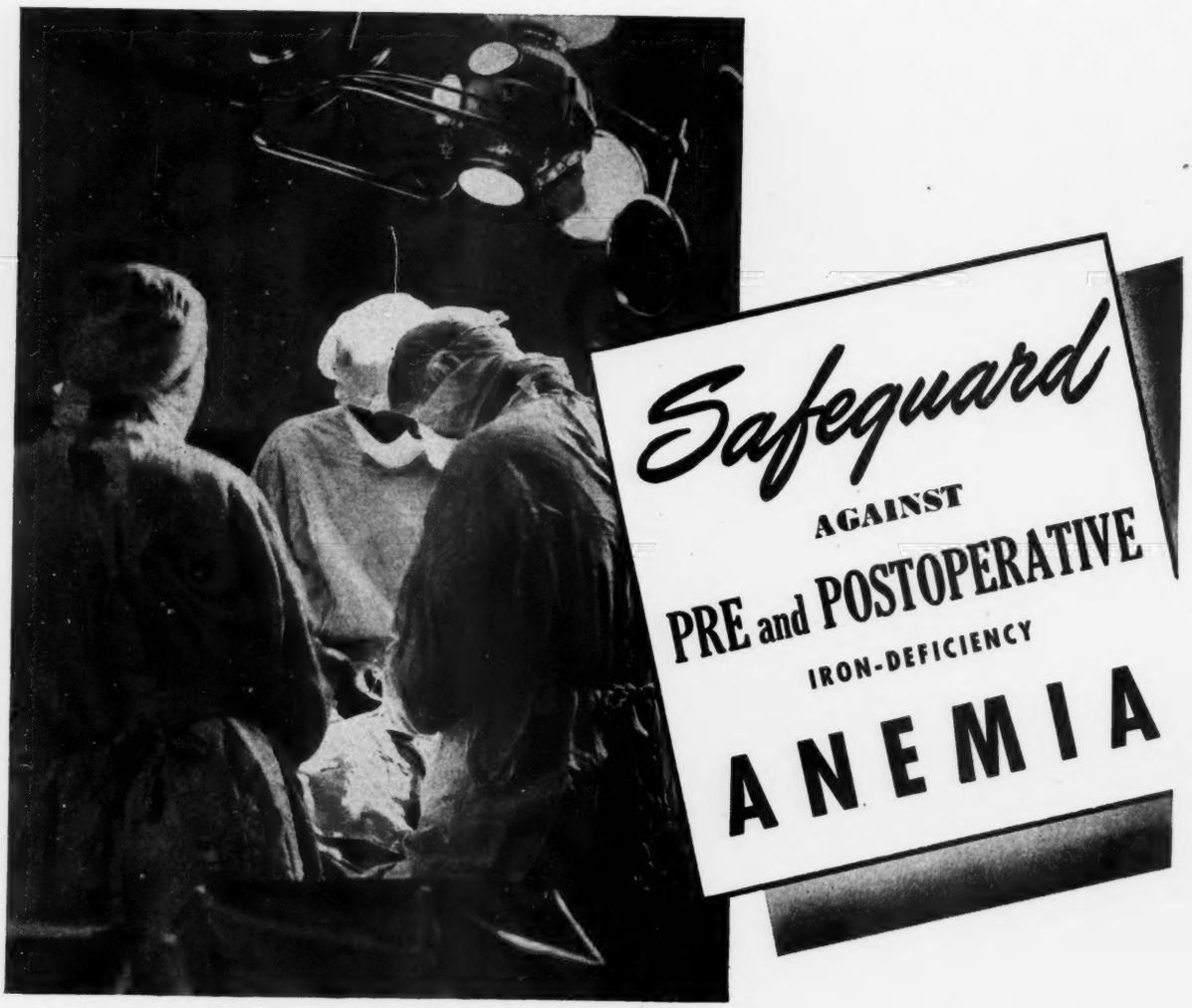

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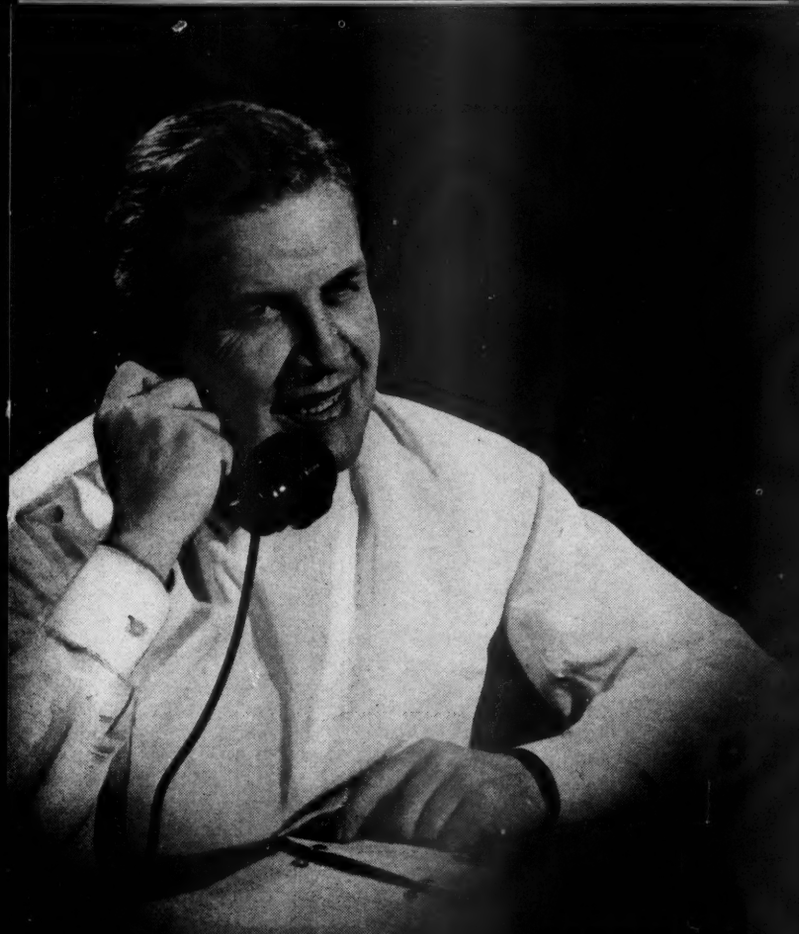

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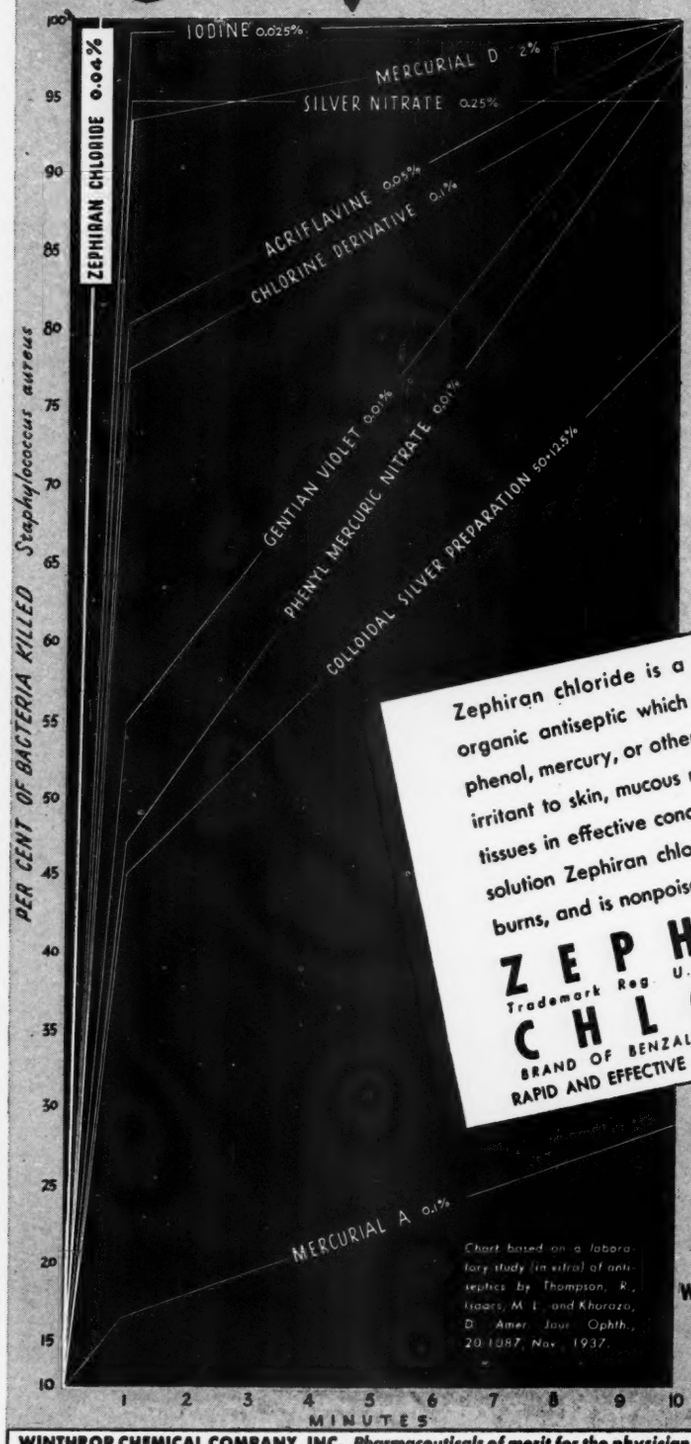


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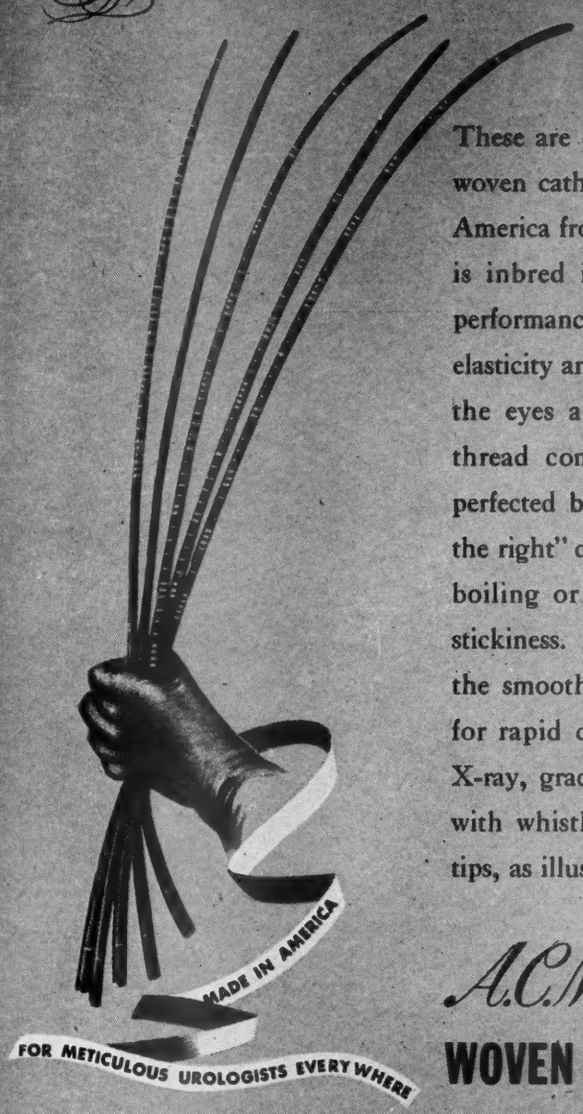


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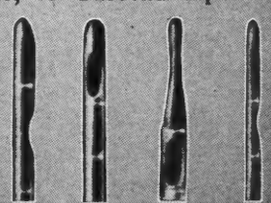

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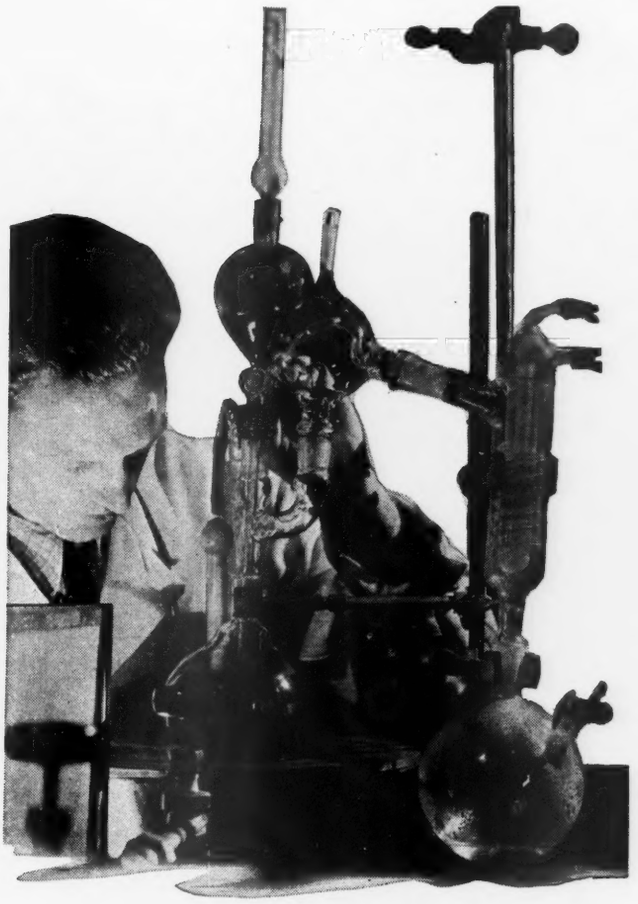

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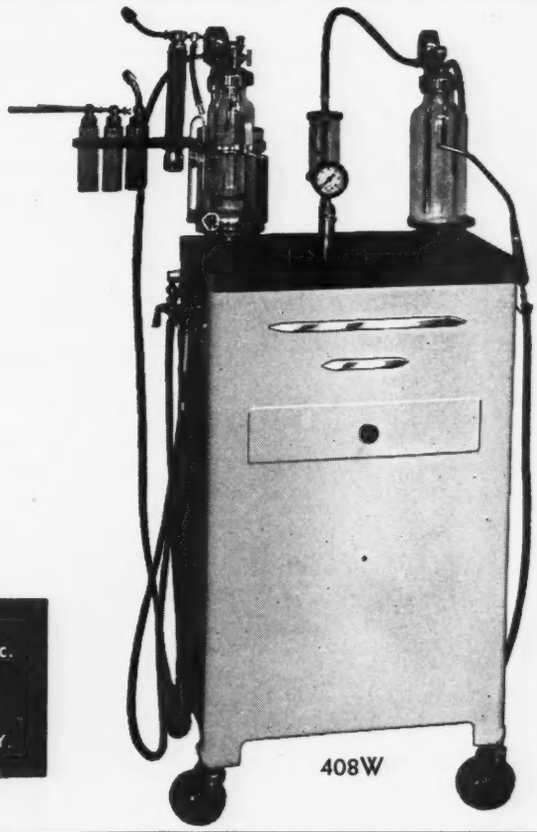

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Characterized by a biographer as a "scientific Ulysses," Brown-Séquard was a member of the famous school of physiologists which included Claude Bernard and Charles Robin. His sublimely imaginative experiments on the functions of the suprarenal glands and the gonads paved the way to fuller understanding of the nature of the endocrine secretions.


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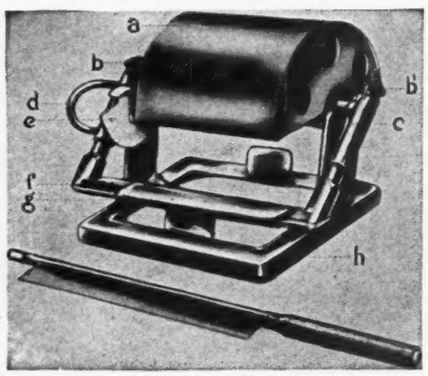


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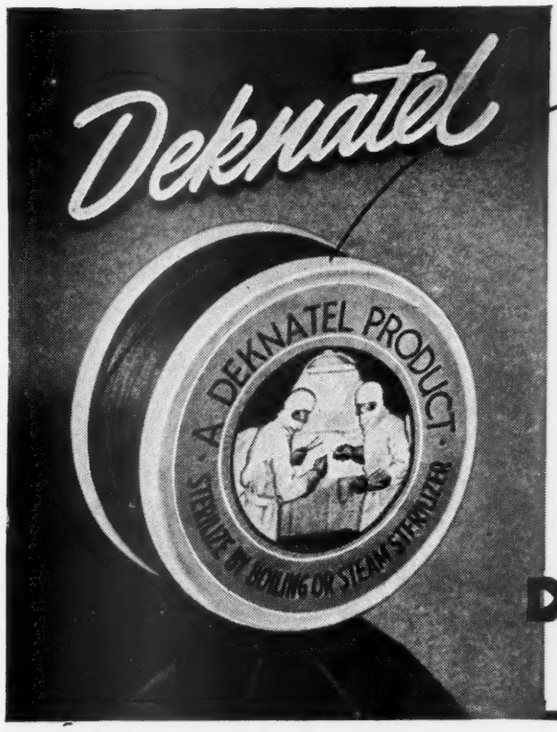


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## OF THE AGED

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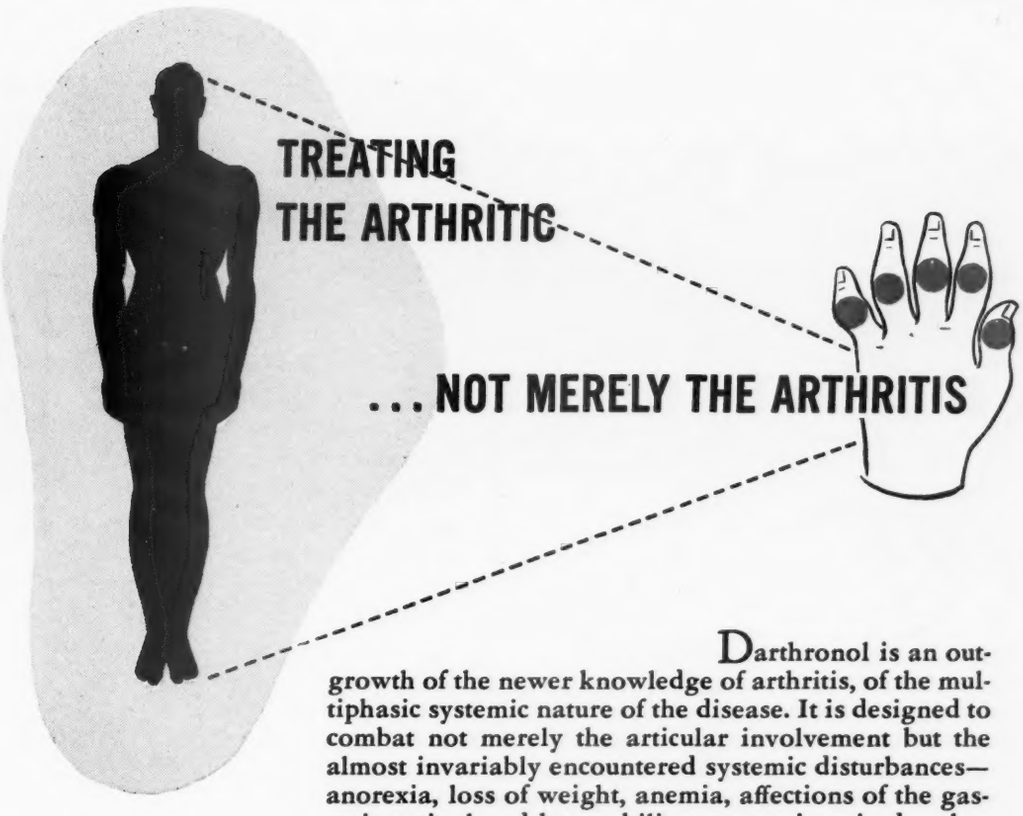

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## ADVERTISERS INDEX


### Instruments and Apparatus

A. S. Aloe Company ..... 47
American Cystoscope Makers, Inc. ... 11, 39
American Sterilizer Company ..... 9
Austenal Laboratories, Inc. ..... *October*
Bard-Parker Co., Inc. ..... *October*
Becton, Dickinson & Co. ..... *October*
The Birtcher Corp. ..... 21
Clay-Adams Co., Inc. ..... 14
General Electric X-ray Corp. ..... 6
Fred Haslam & Co., Inc. ..... 1
The Kansas City Assemblage Co. ..... 46
Kny-Scheerer Corp. ..... 12
Geo. P. Pilling & Son Co. ..... 19
Propper Manufacturing Co. ..... *October*
Singer Sewing Machine Company. ..... 18
J. Sklar Manufacturing Co. ..... 10
C. M. Sorensen Co., Inc. ..... 45
The Tower Co., Inc. ..... 13
Weck Manufacturing Co. ..... *October*

### Sutures

The Armour Laboratories. *Insert Facing Page* 12, 8
Bauer & Black ..... 7
Davis & Geck, Inc. ..... *Insert Facing 2nd Cover*
J. A. Deknatel & Sons, Inc. ..... 47
Ethicon Suture Laboratories. . . *Insert Facing P.* 32
Gudebrod Bros. Silk Co., Inc. ..... *October*

### Pharmaceuticals

Abbott Laboratories ..... 29
American Hospital Supply Corp. ..... *October*
The Arlington Chemical Company. ... *October*
The Armour Laboratories ..... 8
Ernst Bischoff Co., Inc. ..... *October*
Bristol Laboratories ..... *October*
Bristol-Myers Company ..... 49
Burroughs Wellcome & Co. ..... 30
Chatham Pharmaceuticals, Inc. ..... 37
Ciba Pharmaceutical Products, Inc. . . *Back Cover*
Commercial Solvents Corporation. ... *October*
Davis Emergency Equipment Co., Inc. . 22
E. Fougera & Co., Inc. ..... *October*
The Harrower Laboratory, Inc. ..... 46
Hoffmann-La Roche, Inc. ..... 5
Hynson, Westcott & Dunning. ..... *October*
Iodine Educational Bureau, Inc. ..... 48
Lanteen Medical Laboratories, Inc. ... 52
The Lavoris Company ..... 48
Thos. Leeming & Co., Inc. ..... *October*
Eli Lilly and Company ..... 31
The S. E. Massengill Company ..... 42
Merck & Company ..... 41
The Wm. S. Merrell Company ..... 25
McNeil Laboratories, Inc. ..... 34
National Drug Co. ..... *October*
Ortho Products, Inc. ..... 54
Parke, Davis & Co. ..... 24
J. B. Roerig & Company ..... 51
Schering Corporation ..... 27
Smith, Kline & French Laboratories. . . *October*
E. R. Squibb & Sons ..... 28
Frederick Stearns & Company ..... 23
The Upjohn Company ..... 26
Myron L. Walker Co., Inc. ..... 36
Wallace & Tiernan Products, Inc. ..... 45
Wm. R. Warner & Co., Inc. ..... 35
White Laboratories, Inc. ..... 16-17, 43, 53
Winthrop Chemical Co., Inc. ..... 2, 38
Wyeth, Inc. ..... 32

### Hospital Supplies

A. S. Aloe Company ..... 47
American Hospital Supply Corp. ..... *October*
Becton, Dickinson & Co. ..... *October*
Cutter Laboratories ..... 33
General Electric X-ray Corp. ..... 6
Fred Haslam & Co., Inc. ..... 1
Johnson & Johnson ..... 15
Macalaster Bicknell Company ..... 20
Mallinckrodt Chemical Works ..... *October*
J. Sklar Manufacturing Co. ..... 10
C. M. Sorensen Co., Inc. ..... 45
The Tower Co., Inc. ..... 13

### Post-Graduate Instruction

Cook County Grad. Sch. of Med. ..... 44
N. Y. Polyclinic Med. School ..... 44

### Foods

Cereal Institute Inc. ..... *October*
The Wander Company ..... 50

### Miscellaneous

U. S. Treasury ..... 40

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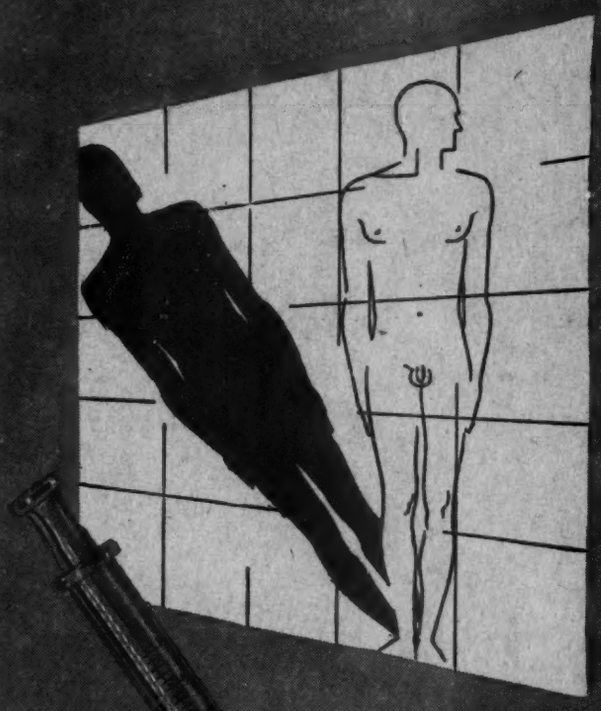
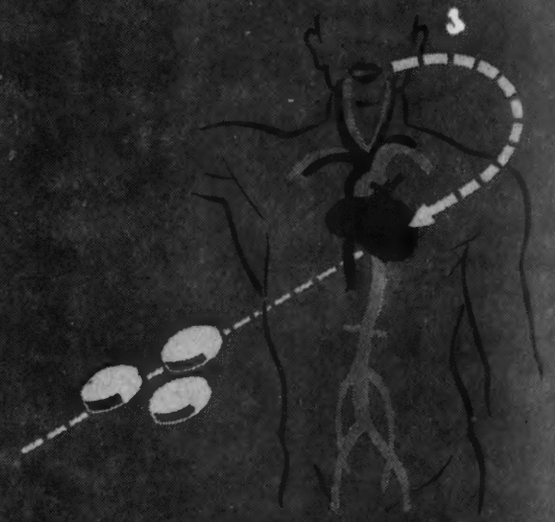
(PER ORAL AND PARENTERAL)





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